

**DATA REPORT  
PROJECT SHOAL AREA  
CHURCHILL COUNTY, NEVADA**

DOE Nevada Operations Office  
Las Vegas, Nevada

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**DATA REPORT  
PROJECT SHOAL AREA  
CHURCHILL COUNTY, NEVADA**

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## ***List of Acronyms and Abbreviations***

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AIP	Analysis in process
bgs	Below ground surface
CAIP	Corrective Action Investigation Plan(s)
CAS	Corrective Action Site(s)
CAU	Corrective Action Unit(s)
CFR	<i>Code of Federal Regulations</i>
cm	Centimeter(s)
COC	Chain of Custody
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DRI	Desert Research Institute
FFACO	<i>Federal Facility Agreement And Consent Order</i>
FMP	Fluid Management Plan
ft	Foot (feet)
ft <sup>3</sup>	Cubic foot (feet)
gpm	Gallon(s) per minute
id	Inside diameter
in.	Inch(es)
IT	IT Corporation
L/min	Liter(s) per minute
LiBr	Lithium Bromide
m	Meter(s)
m <sup>3</sup>	Cubic meter(s)
MCL	Maximum Contaminate Level(s)
min/ft	Minutes per foot (feet)
mg/kg	Milligram(s) per kilogram
mg/L	Milligram(s) per liter
MSDS	Material Safety Data Sheet(s)
NA	Not Analyzed
ND	Not detected
NDEP	Nevada Division of Environmental Protection
NDWS	Nevada Drinking Water Standards
NTS	Nevada Test Site
od	Outside diameter

## ***List of Acronyms and Abbreviations*** (Continued)

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pCi/L	PicoCurie(s) per Liter
PS	Post Shot
PSA	Project Shoal Area
psi	Pound(s) per square inch
QC	Quality control
SGZ	Surface Ground Zero
SSHASP	Site-Specific Health and Safety Plan
SVOC	Semivolatile organic compound(s)
TCLP	Toxicity Characteristic Leaching Procedure
TD	Total depth
TPH	Total Petroleum Hydrocarbon(s)
VOC	Volatile organic compound(s)
Xe	Xenon
°C	Degree(s) Celsius

## 1.0 Introduction

---

This preliminary data report presents the field data collected by IT Corporation (IT) between September 4 and November 14, 1996, as part of the implementation of the *Corrective Action Investigation Plan (CAIP) for the Project Shoal Area, CAU No. 416 (PSA)* (DOE/NV, 1996a). The CAIP is part of an ongoing U.S. Department of Energy (DOE)-funded project for the investigation of Corrective Action Units (CAU) No. 416 surface and No. 447 subsurface, PSA. All work conducted on this project was conducted in accordance with the *Federal Facility Agreement and Consent Order (FFACO)* of 1996, the *Resource Conservation and Recovery Act Industrial Sites Quality Assurance Plan* (DOE, 1994) and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations (NDEP, 1992).

The PSA covers 10.36 square kilometers (4.0 square miles) and is located in northwestern Nevada approximately 48.28 kilometers (30.0 miles) southeast of the town of Fallon, in the northern portion of the Sand Springs Range in Churchill County, Nevada ([Figure 1-1](#)). The PSA was active during the early to mid-1960s as the site of a single underground nuclear test, Project Shoal. The test was conducted to determine whether seismic waves produced from an underground nuclear test could be differentiated from those resulting from earthquakes.

### 1.1 Purpose

The purpose of this field investigation was to investigate surface and subsurface areas possibly contaminated by the Project Shoal Nuclear Test and associated activities. The purpose of the surface investigation was to determine if drilling materials contained within the PSA mud pit were contaminated and, if so, to determine the nature and extent of contamination. The results of this surface investigation would be used to develop an appropriate corrective action for CAU No. 416.

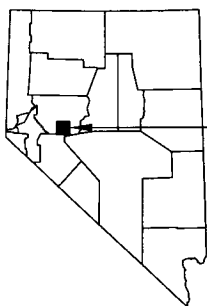
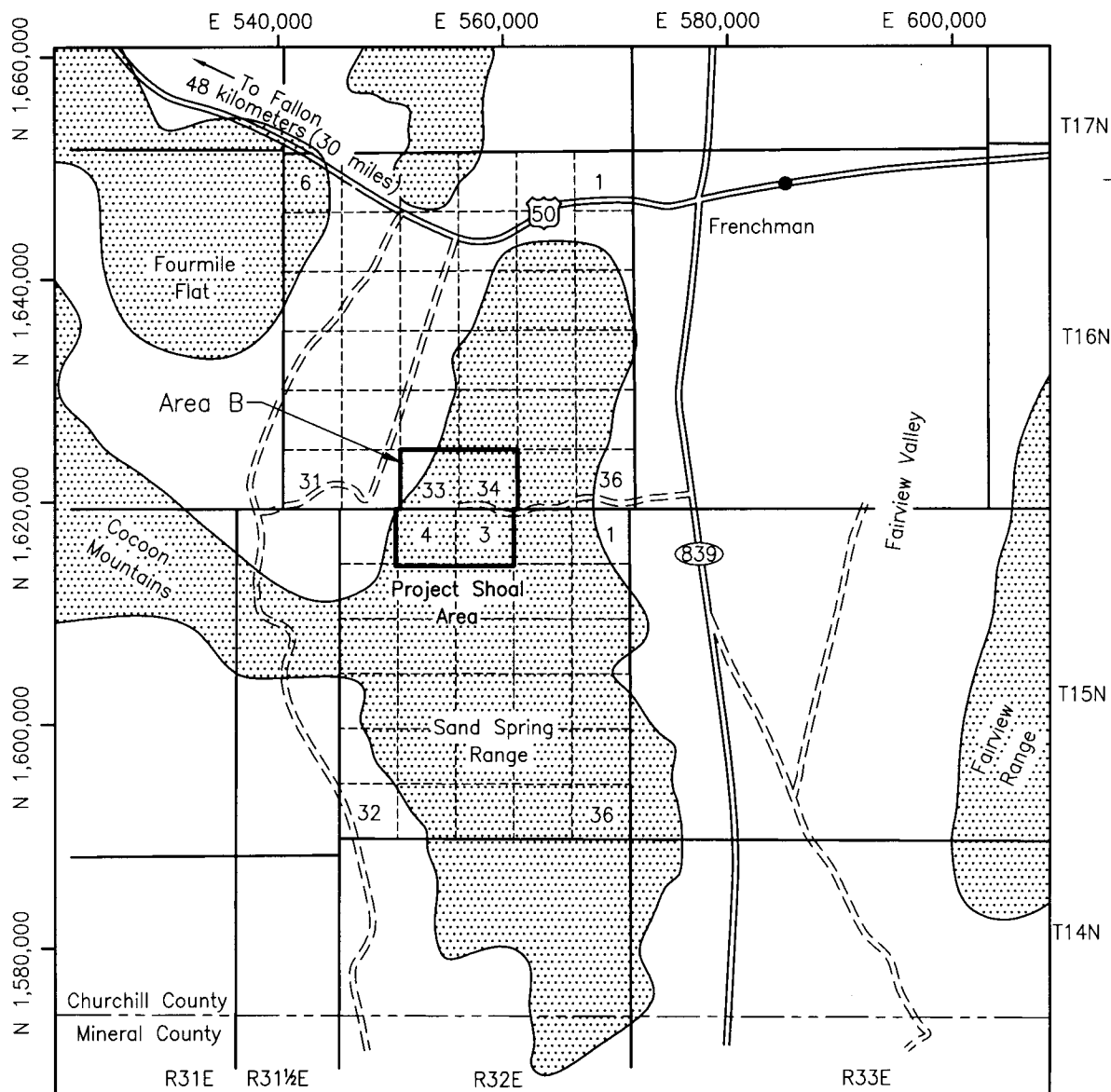
The purpose of the subsurface investigation was to collect aquifer and groundwater data to aid in the modeling of groundwater flow and contaminant transport. The resulting model will be used to establish the boundary for CAU No. 447.

## **1.2 Scope of Work**

The scope of the surface investigation included soil sampling from the mud pit and surrounding area. Twelve soil borings were advanced within the mud pit; three soil borings were advanced upgradient; and three were advanced downgradient of the mud pit. Discrete soil samples were obtained from individual borings to characterize mud pit material, natural soils, and bedrock below and proximal to the mud pit.

The scope of the subsurface investigation included constructing drill pads and lined fluid storage sumps for drilling, drilling four groundwater monitoring wells to depths in excess of 396.24 meters (m) (1,300 feet [ft]) below ground surface (bgs), collecting hydrologic data during drilling, regularly monitoring discharged drilling effluent for radionuclides, conducting downhole geophysical logging of the open boreholes, casing the boreholes above the potentiometric surface, developing the wells, and collecting groundwater samples from the developed wells. Upon completing drilling and casing operations, water levels were monitored to determine recovery rates and the static water level of each well.

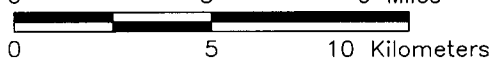
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Project Shoal Area

Area A: Right of entry  
Area B: Land withdrawn  
T16N, R32E, Sections 33 and 34,  
T15N, R32E, Sections 3 and 4.

SCALE



Source: DRI, 1988; Public Land Order #2834, December 1962

#### LEGEND

- == Improved roadway
- == Unimproved roadway
- Township/range boundary
- - - County line
- - - Section line
- Land withdrawal boundary
- Town
- ▨ Mountain ranges

**Figure 1-1**  
**Project Shoal Area Location Map**

## **2.0 Surface Investigation CAU No. 416**

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The Shoal Mud Pit, Corrective Action Site (CAS) Number 57-09-01, is located due east of surface ground zero in a shallow canyon with an earthen dam at the southern end ([Figure 2-1](#)). The Shoal Mud Pit was constructed to hold fluids and cuttings from the Post Shot (PS)-1 vertical borehole that was drilled into the Shoal test cavity in October 1963. Since PS-1 was drilled using bentonite drilling mud, air, and air-mist, the primary constituents of concern in the mud pit are possible radiological contaminants from the Shoal test cavity. Some details of the Shoal test are still classified; however, the known nonclassified radiological contaminants of concern are tritium, strontium<sup>90</sup>, and cesium<sup>137</sup>. Short-lived gaseous radioisotopes of iodine<sup>131</sup>, xenon<sup>133m</sup> (Xe<sup>133m</sup>), and Xe<sup>133</sup>, encountered during the drilling of the post shot, have decayed to below detection limits. These radioisotopes were not detected in the samples collected during the September 1996 sampling event.

Please note that [Figures 2-1 to 2-37](#) and [Tables 2-1 to 2-3](#), cited in the following text, are located at the end of this section.

### **2.1 Purpose**

The purpose of sampling the Project Shoal Area mud pit was to evaluate potential contamination and to determine the vertical and horizontal extent of the mud pit. Eighteen locations were sampled in and around the mud pit by the direct-push method ([Figure 2-2](#)).

### **2.2 Scope of Work**

The mud pit characterization activity was conducted from September 5 through 8, 1996, and September 15 and 16, 1996. Gregg Drilling Company of Signal Hill, California, was subcontracted to do the direct-push borings, under the direction of IT.

Before sampling the mud pit, a control point was established at the approximate middle of the earthen dam, and sample locations were measured out in a 6.10-m (20.0-ft) grid pattern within the mud pit. A total of ten soil borings (DP-1 to DP-9, and DP-18) were taken to characterize the mud pit. Three soil borings (DP-12, DP-13, and DP-14) were taken downgradient on the south side of the earthen dam; three (DP-15, DP-16, and DP-17) were taken from approximately 152.40-m (500.0-ft) upgradient in the canyon; and one boring each was taken from outside the east (DP-10) and west (DP-11) edges of the mud pit ([Figure 2-2](#)).

Soil borings were completed using direct-push techniques. This method incorporates a hydraulic percussion hammer which drives a 0.61-m (2.0-ft) long sampling rod to the required depth. The rod is hollow with four 15.24-centimeter (cm) (6.0-inch [in.]) long, 2.54-cm (1.0-in.) diameter, stainless steel sampling sleeves. The soil is forced into the sleeves as the hammer drives the sampler into the ground. When the sampling sleeves were removed from the drive rod, the ends of each 15.24-cm (6.0-in.) long sleeve were inspected and logged by the IT site geologist. A cap was placed on each end of the sampling sleeve until the boring was completed and the soil in the sleeves could be composited for sampling. After the soil was composited, it was placed in the sample jars, labeled, and placed on ice. Samples were handled according to ITLV Standard Quality Practices (IT, 1996).

A composite sample was collected from all material recovered from each direct-push sampling location. In order to obtain adequate sample volume, it was necessary to advance more than one boring at a location; the additional borings were done within a 30.5-cm (1.0-ft) radius of the initial boring. The sample sleeves were only 2.54 cm (1.0 in.) in diameter, and the maximum push depth was less than 1.22 m (4.0-ft).

The soil borings revealed that the mud pit has a maximum thickness of 0.61 m (2.0 ft) in the center and thins towards the edges. The direct-push sampling rod was usually refused when the granite bedrock was encountered at a depth of generally less than 1.22-m (4.0-ft) below the mud pit's surface. There was no obvious contact between the mud pit floor and the native soil. Mud pit material was distinguished from the background soil based on a change in grain size and material color. Where samples were required to analyze the soil below the mud pit, a composite sample was collected from the deepest sample sleeves that contained only native soil and no mud pit material. Soil boring logs for direct-push borings DP-1 through DP-18 are illustrated in [Figures 2-20 through 2-37](#). [Figure 2-3](#) is a plan view of the mud pit showing sampling locations, and [Figures 2-4 through 2-7](#) are cross sections of the mud pit.

Shallow mud pit samples DP-1, DP-3, DP-4, DP-6, DP-7, DP-9, and DP-18 were analyzed for gross alpha, gross beta, total barium, total chromium, tritium, gamma spectroscopy, and Total Petroleum Hydrocarbon (TPH) diesel. Deep mud pit samples (DP-1, DP-5, DP-7, DP-9, and DP-18) were analyzed for gross alpha, gross beta, tritium, and gamma spectroscopy. Soil boring locations DP-2, DP-5, and DP-8 were waste management samples and were analyzed for gross alpha, gross beta, Toxicity Characteristic Leaching Procedure (TCLP) metals, tritium, gamma spectroscopy, TPH diesel, TCLP semivolatile organic compounds (SVOCs), and TCLP volatile organic compounds (VOCs). Direct-push borings (DP-10 and DP-11), which are adjacent to the

mud pit, and downgradient borings (DP-12 to DP-14) were analyzed for gross alpha, gross beta, tritium, and gamma spectroscopy. Soil borings DP-15 to DP-17, upgradient, were analyzed for gross alpha, gross beta, total barium, total chromium, and gamma spectroscopy. The following quality control (QC) samples were collected: field duplicates, matrix spike/matrix spike duplicates, field blanks, trip blanks, and equipment decontamination rinsate samples.

Upon completing sampling, Bell and Associates, Land Surveyors, of Fallon, Nevada, were contacted to survey each direct-push boring location. These survey points were established in Nevada State Plane, North American Datum 1927, coordinates.

### **2.3 Summary of Results**

A total of ten shallow soil samples were collected from within the PSA mud pit boundaries. Seven of these samples were analyzed for TPH (diesel fraction and waste oil fraction), total barium, and total chromium. The remaining three samples were analyzed for TPH (diesel fraction and waste oil fraction), TCLP-extractable VOCs, TCLP-extractable SVOCs, and TCLP-extractable metals. These latter three samples were collected for waste management purposes. [Table 2-1](#) summarizes the sample number, the direct-push boring number, and the depth. [Table 2-2](#) contains the sample results from the borings. [Figures 2-8 to 2-19](#) are sample location maps with the concentration of various analytical constituents displayed. Mud Pit QC Analytical Data shows results of the quality control samples. Analytical results for volatile organic compounds for the trip blank samples were all nondetects.

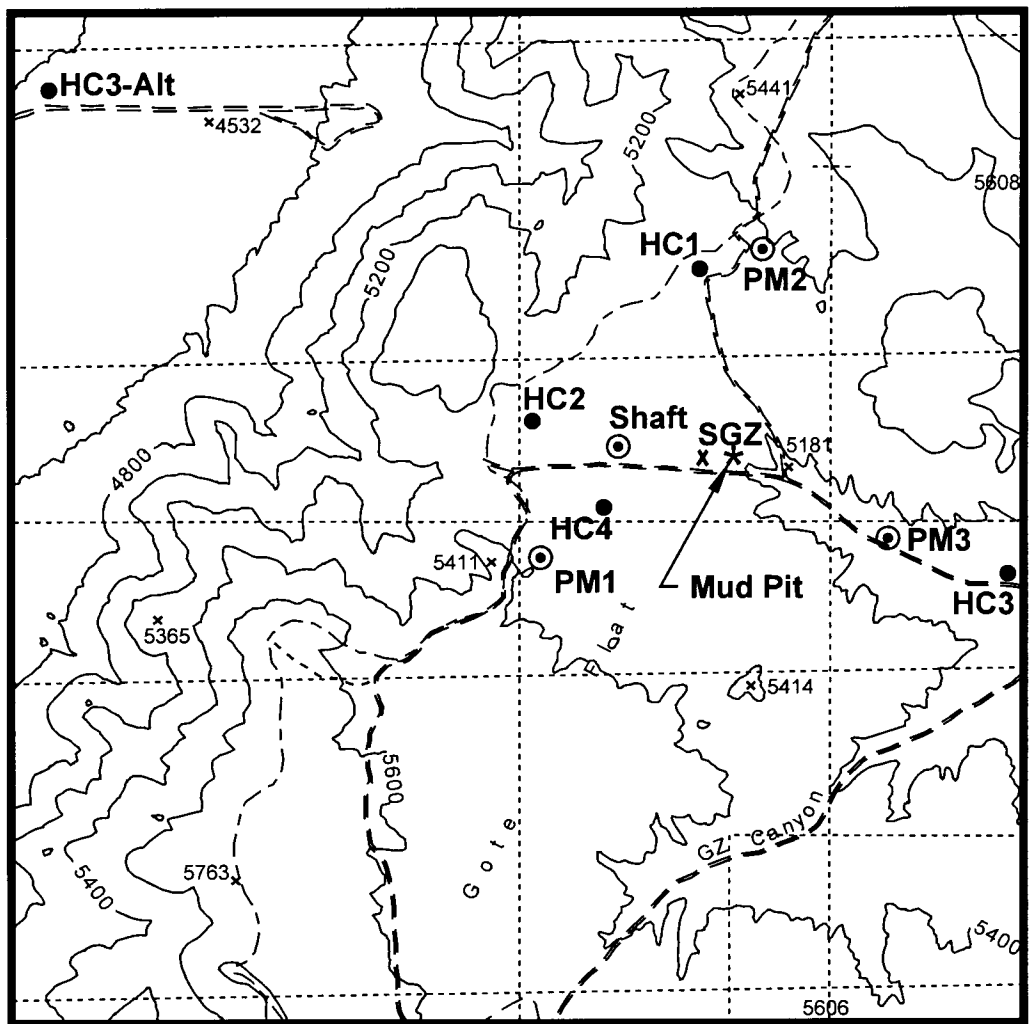
The preliminary action levels for TPH, total barium, and total chromium established in the CAIP (Section 3.5.1) are as follows:

- **TPH** - 100 milligrams per kilogram (mg/kg), which is the NDEP regulatory action level for TPH.
- **Total barium** - 4,000 mg/kg, which is the draft 40 *Code of Federal Regulations* (CFR) 264 Subpart S recommended action level for barium.
- **Total chromium** - 400 mg/kg, which is the draft 40 CFR 264 Subpart S recommended action level for hexavalent chromium. Although hexavalent chromium is not expected to be present in the mud pit soils, there are no Subpart S recommended values for total chromium or trivalent chromium when direct contact is the principal exposure pathway; therefore, the hexavalent chromium value is being used as a conservative action level.
- **Waste Characterization Samples** - The three (3) waste characterization samples were compared to 40 CFR 261.26 toxicity characteristics for classifying hazardous wastes.

The analysis for TPH found waste oil in several samples above the State regulatory limit of 100 mg/kg, while TPH diesel was found above this limit in only two samples (see [Table 2-2](#)). However, the total barium and total chromium levels are well below the proposed Subpart S action levels. None of the analyses for the radiological parameters showed levels above expected background. In addition, the waste characterization sample analyses show that the material is not a hazardous waste.

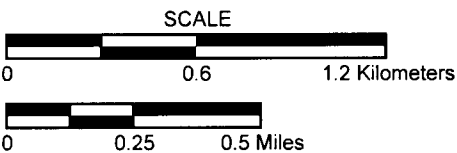
#### **2.4    *Estimated Volume of Pit Material***

The estimated volume of material in the mud pit is approximately 116.21 cubic meters (4,104 cubic feet). The volume was estimated by averaging the depth of the mud pit, 1.52 ft (as encountered in the borings), and multiplying by 2,700 square feet, the estimated surface area of the mud pit. Refer to [Figures 2-3 to 2-7](#) as they illustrate the approximate subsurface extent of the impoundment and the irregular basal contour.



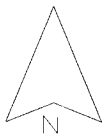
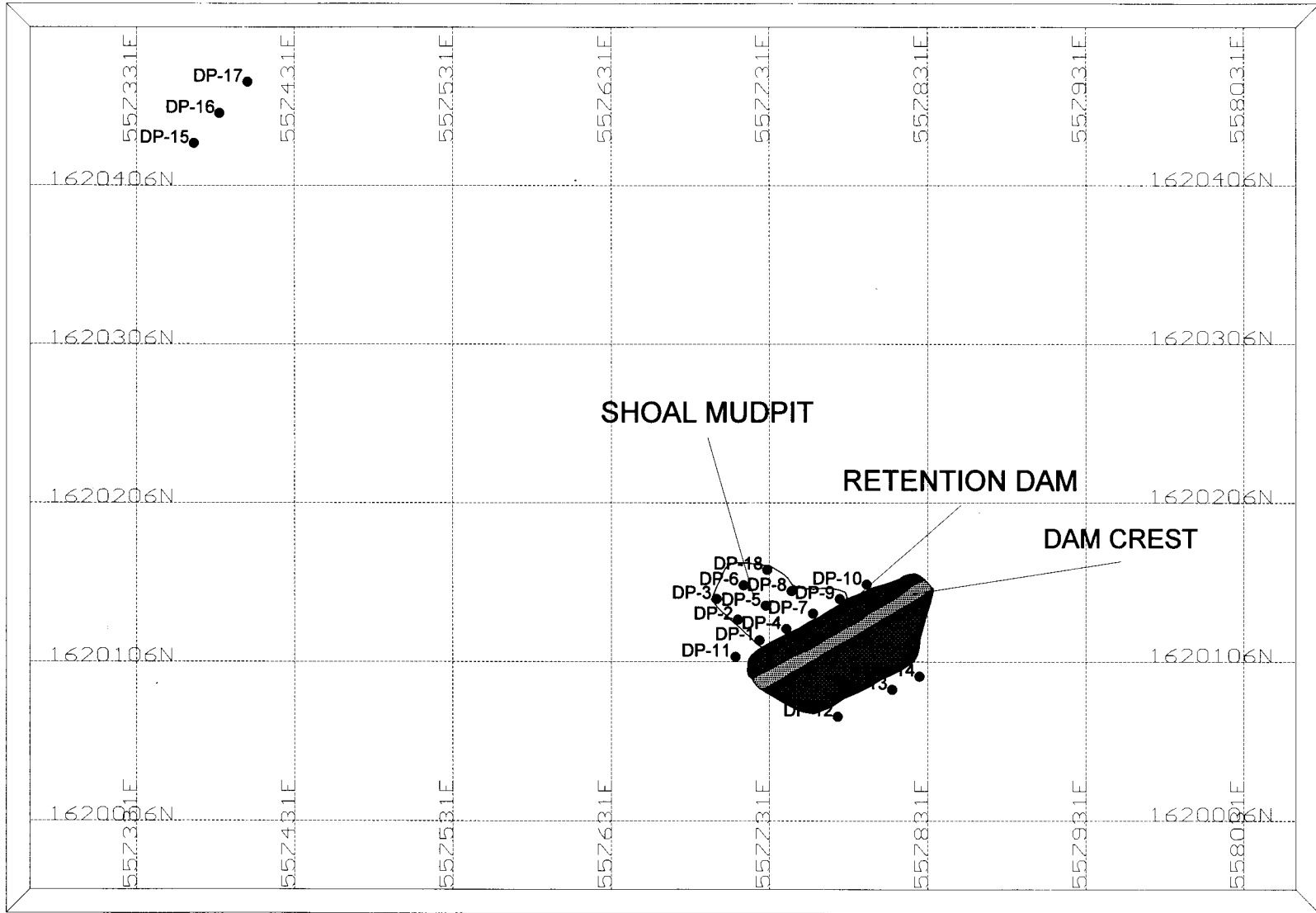
**LEGEND**

- ⊙ Abandoned well or boring
- Proposed well (approximate location)
- \* Shoal Mud Pit (approximate location)
- Withdrawn area boundary
- Topographic contour (Interval = 200 feet)
- x5365 Point elevation
- - - Unpaved road
- xSGZ Surface ground zero
- - - Approximate location of groundwater divide



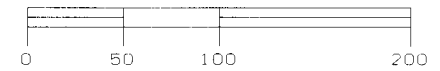
Source: DOE, 1996

**Figure 2-1  
Shoal Mud Pit Location Map**



PROJECT SHOAL AREA

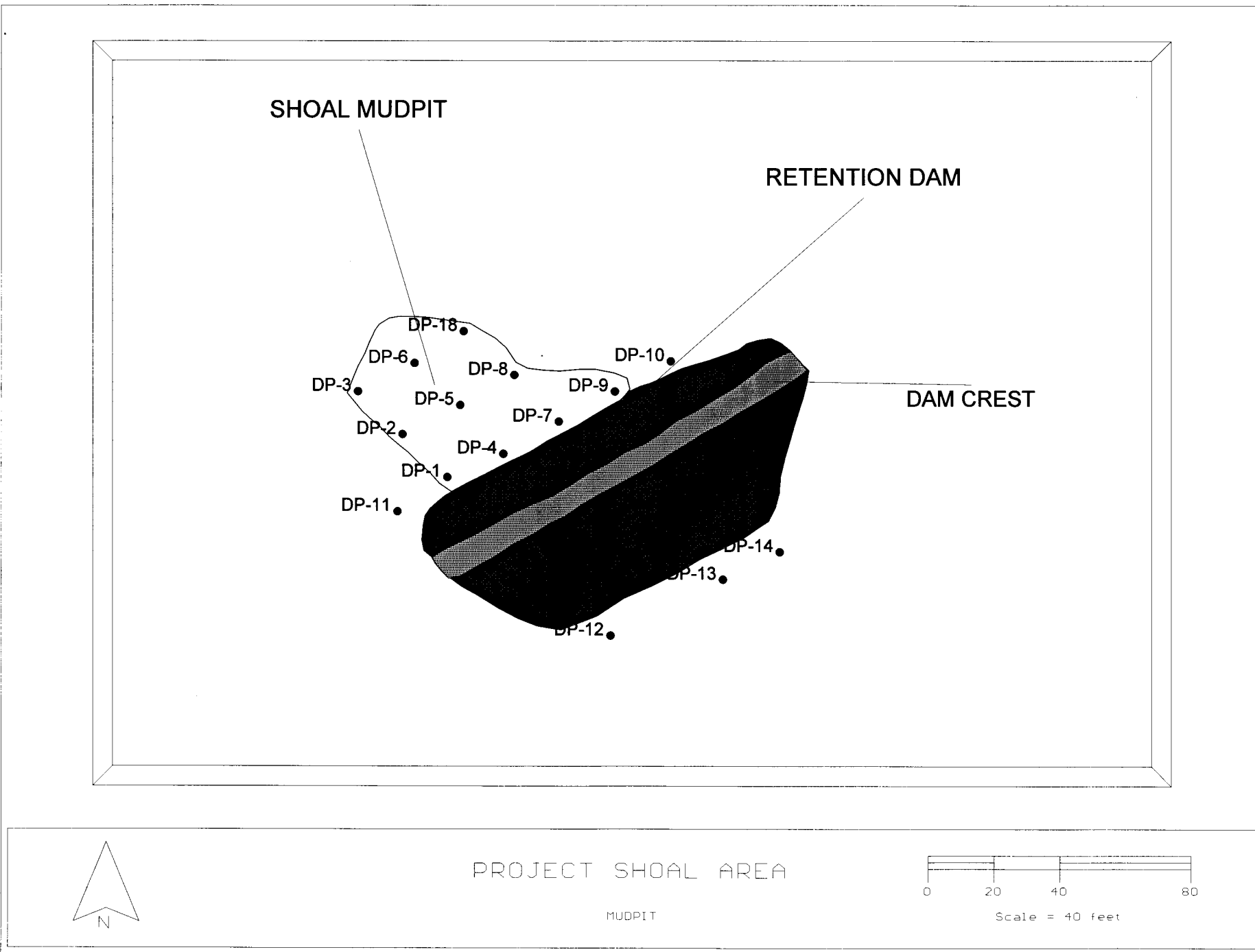
SAMPLE LOCATION MAP



Scale = 100 feet

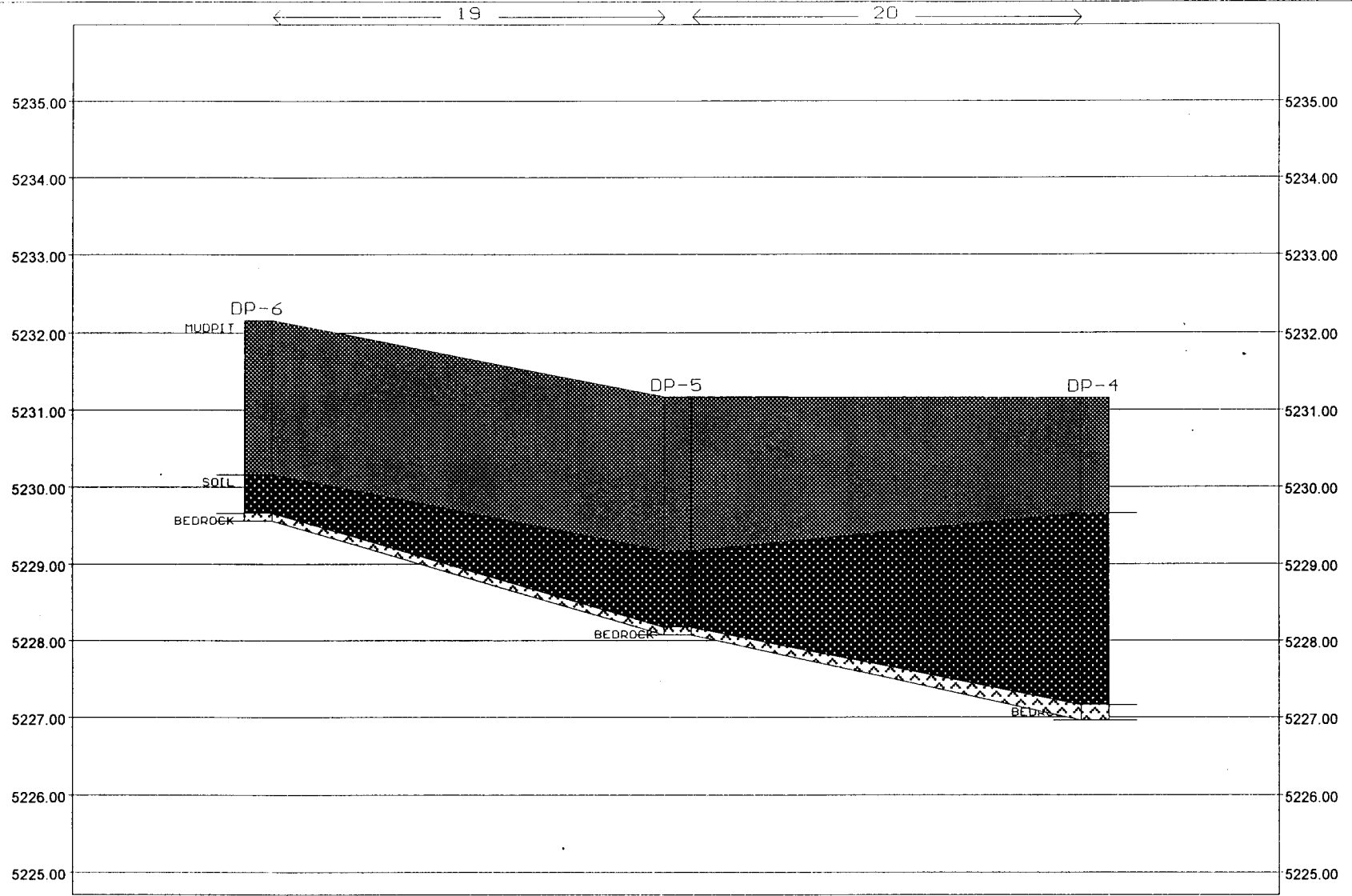
**Figure 2-2**  
**Shoal Mud Pit Sample Location Map with Upgradient Locations**  
**2-6**

Figure 2-3  
Shoal Mud Pit Sample Location Map  
2-7



Cross Section Mud 1 - Borings DP-6, DP-5, DP-4

Figure 2-4



PROJECT SHOAL AREA

X-SEC. MUD 1

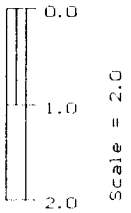


Figure 2-5  
 Cross Section Mud 3 - Borings DP-18, DP-6, DP-3  
 2-9

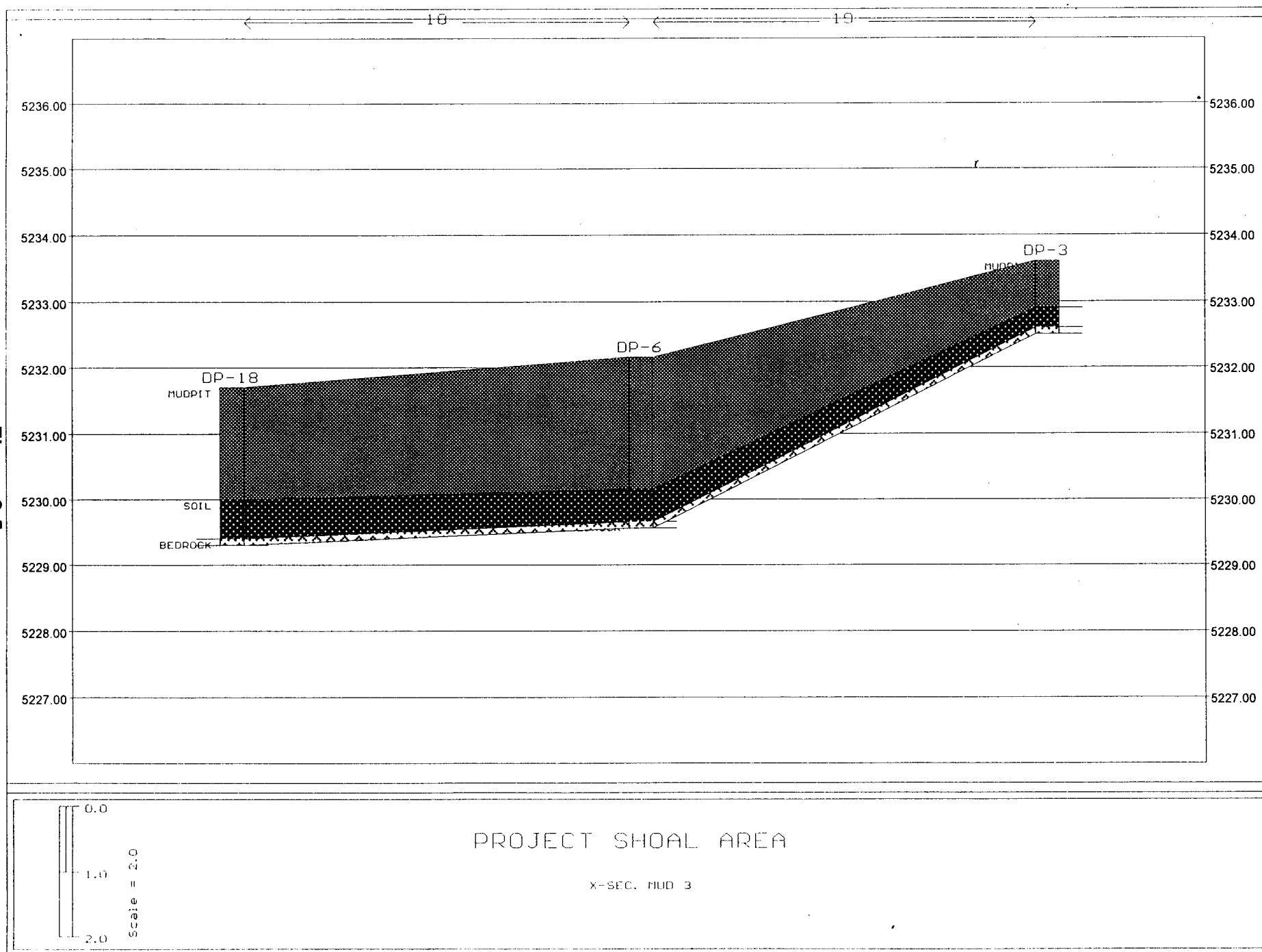


Figure 2-6  
 Cross Section Mud 4 - Borings DP-8, DP-5, DP-2  
 2-10

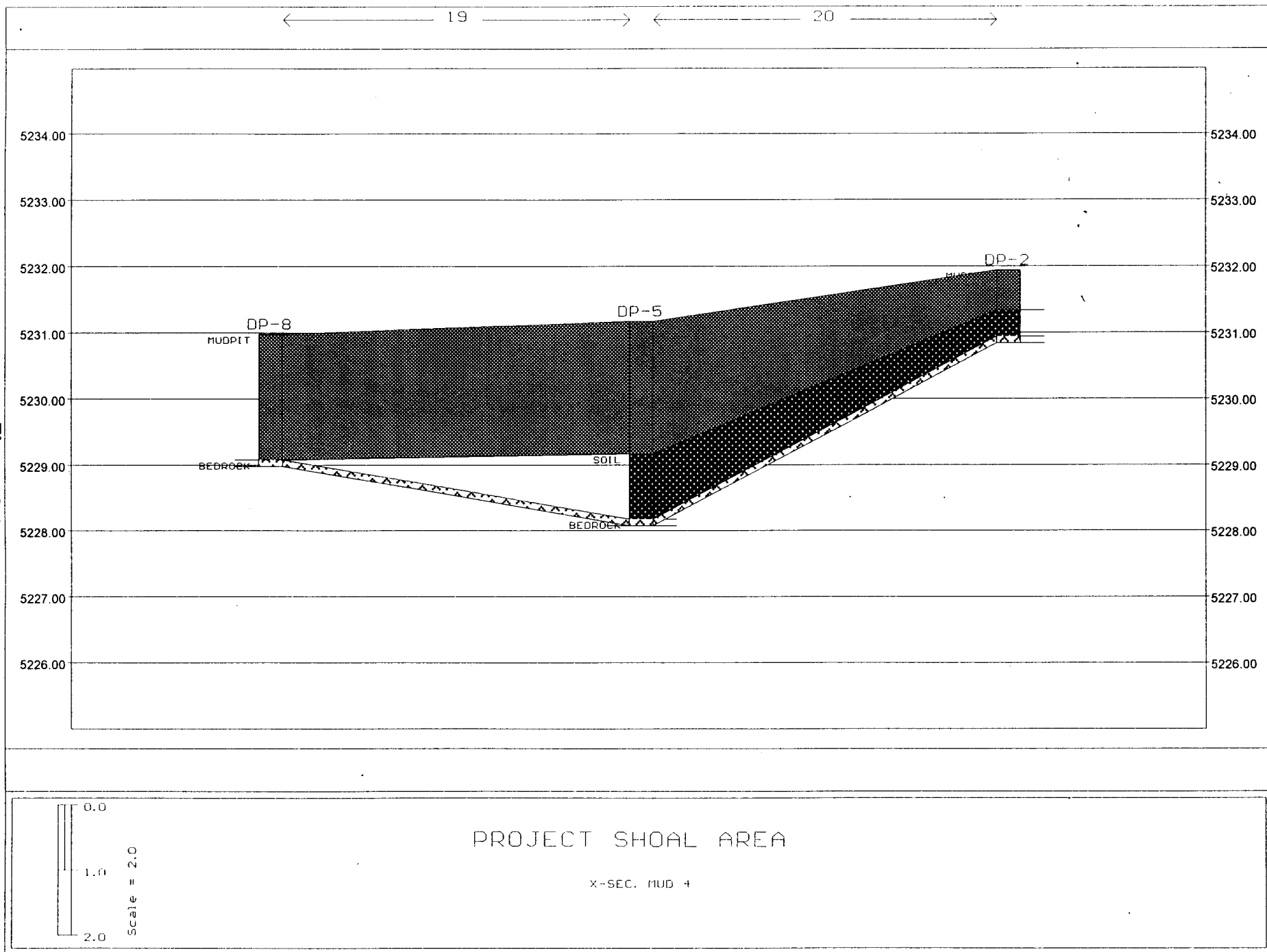
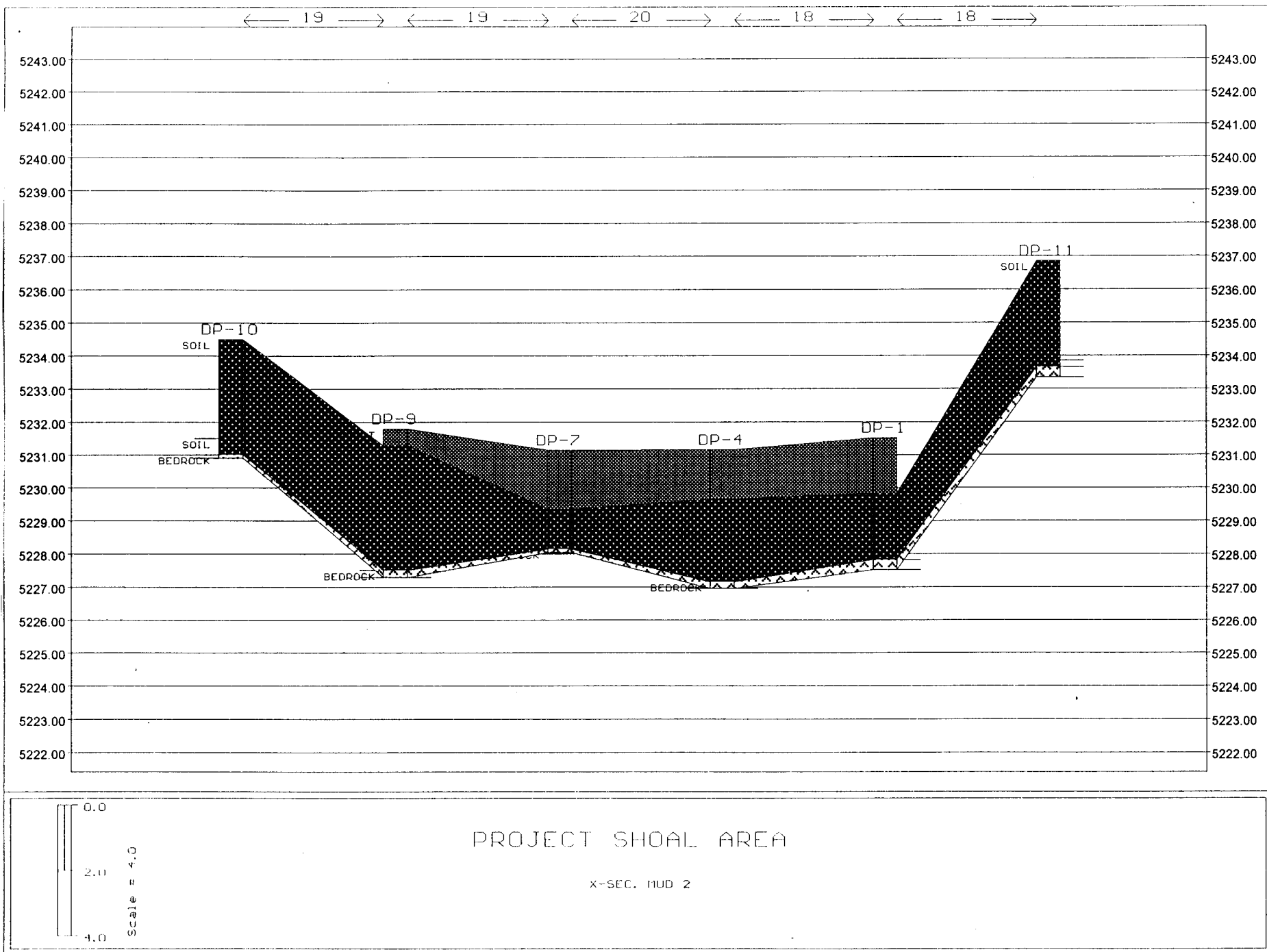


Figure 2-7  
 Cross Section Mud 2 - Borings DP-10, DP-9, DP-7, DP-4, DP-1, DP-11  
 2-11



## Explanation for Figures 2-8 to 2-19

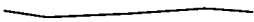
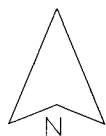
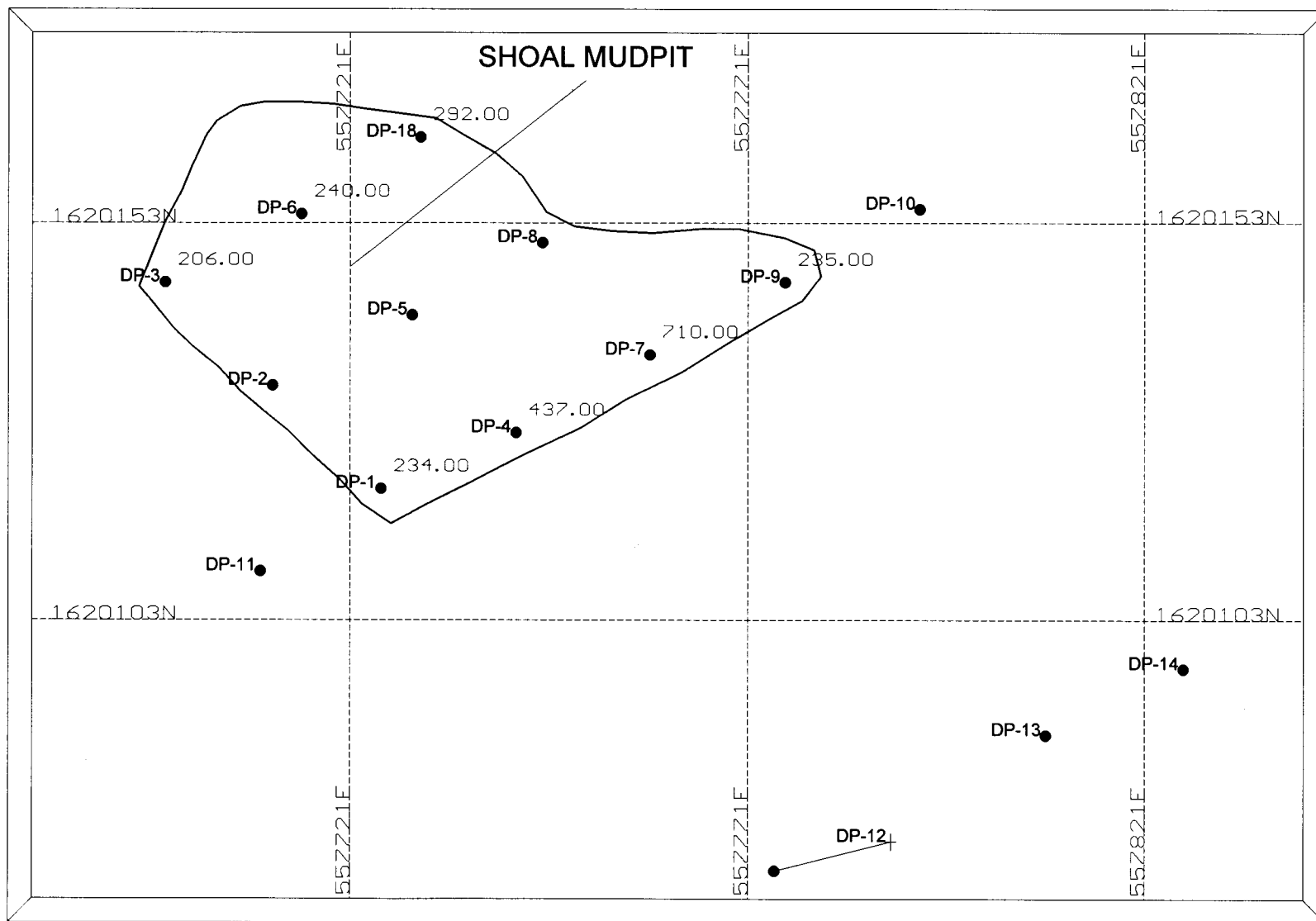
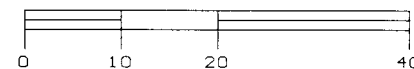
— — — — 1620103N	Nevada State Planar Northing and Easting Grid
	Outline showing extent of shoal mudpit
<b>DP-1 ●</b>	Boring number with direct push soil sampling location
234.00	Highest concentration of constituent detected in that boring

Figure 2-8  
Shoal Mud Pit Analytical Concentration Map of Barium



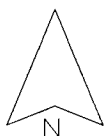
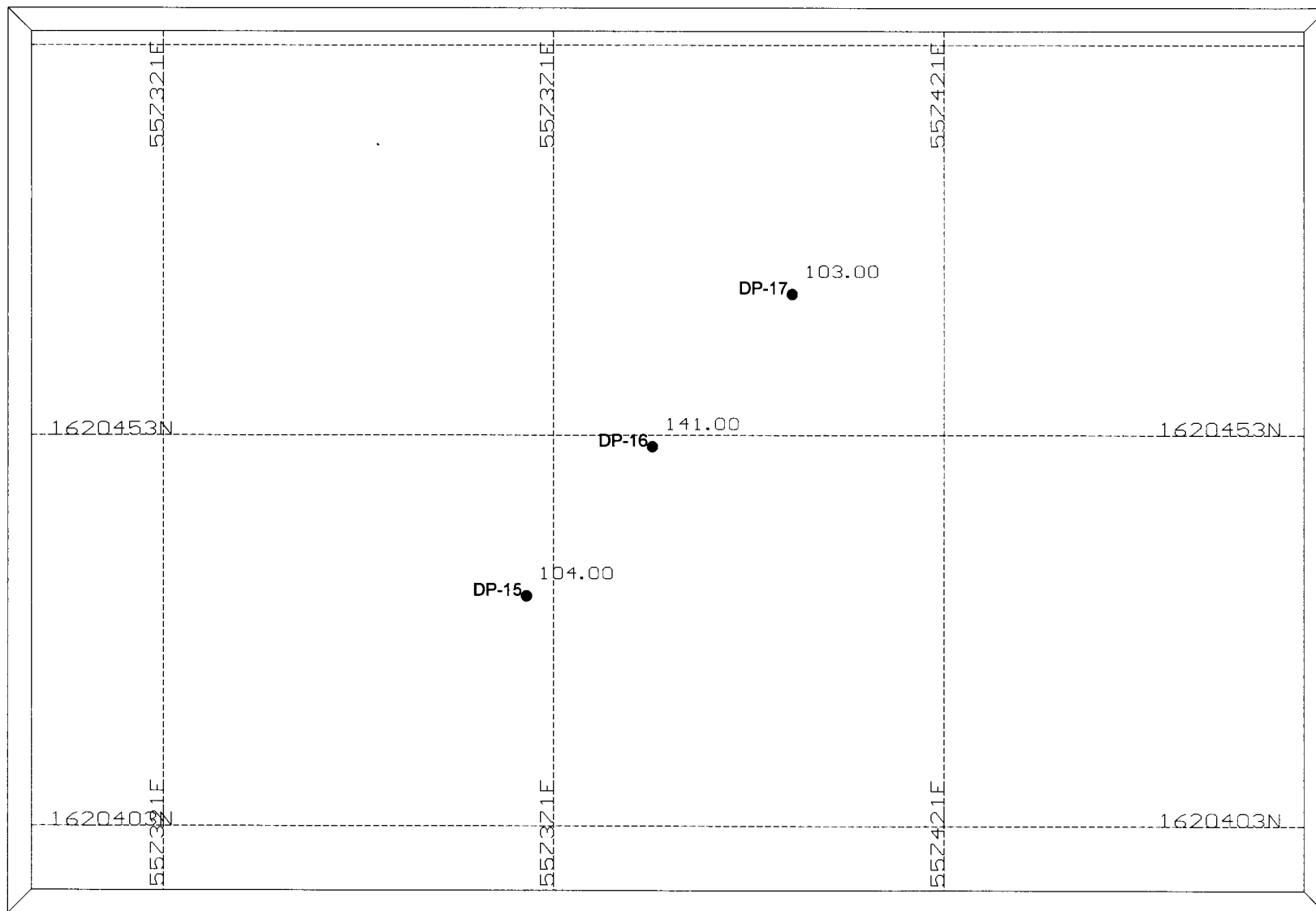
SHOAL PROJECT/MUDPIT

BARIUM > 1 MG/KG



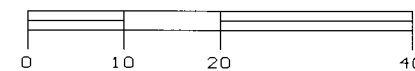
Scale = 20 feet

**Figure 2-9**  
**Upgradient Analytical Concentration Map of Barium**



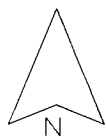
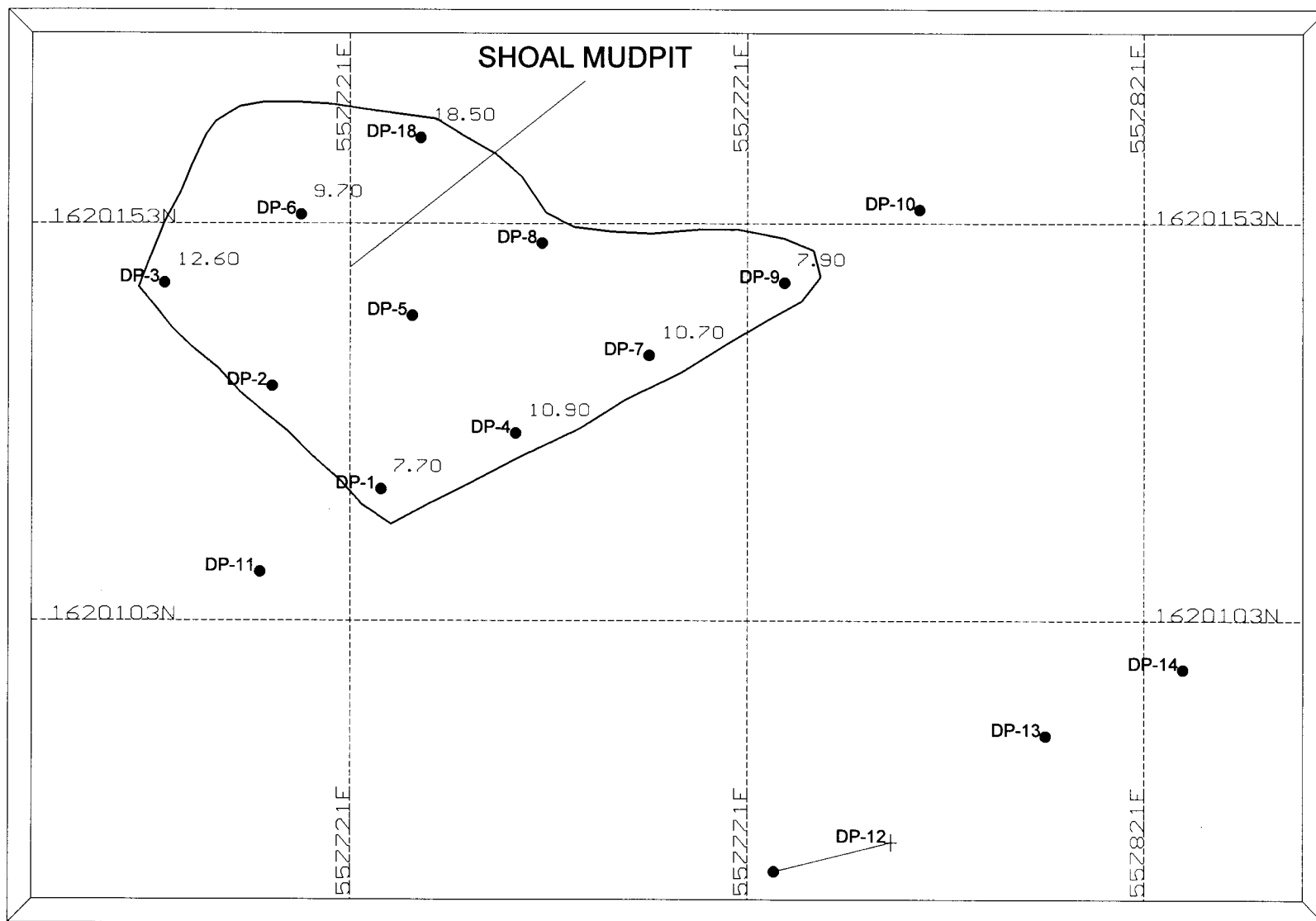
SHOAL PROJECT/MUDPIT

BARIUM > 1 MG/KG



Scale = 20 feet

Figure 2-10  
Shoal Mud Pit Analytical Concentration Map of Chromium



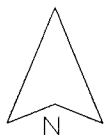
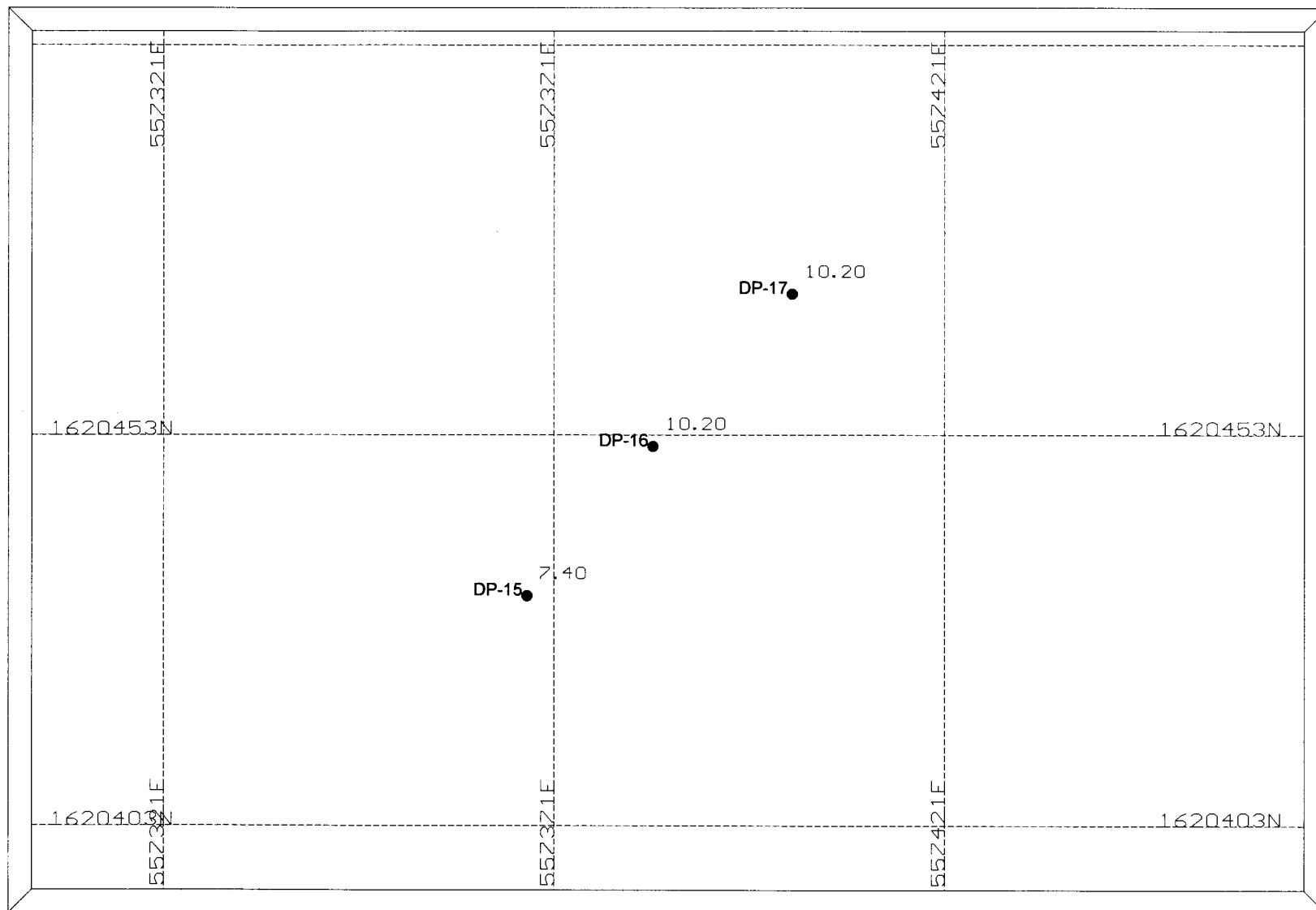
SHOAL PROJECT/MUDPIT

CHROMIUM > 1 MG/KG



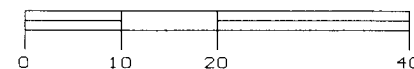
Scale = 20 feet

**Figure 2-11**  
**Upgradient Analytical Concentration Map of Chromium**



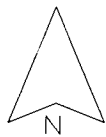
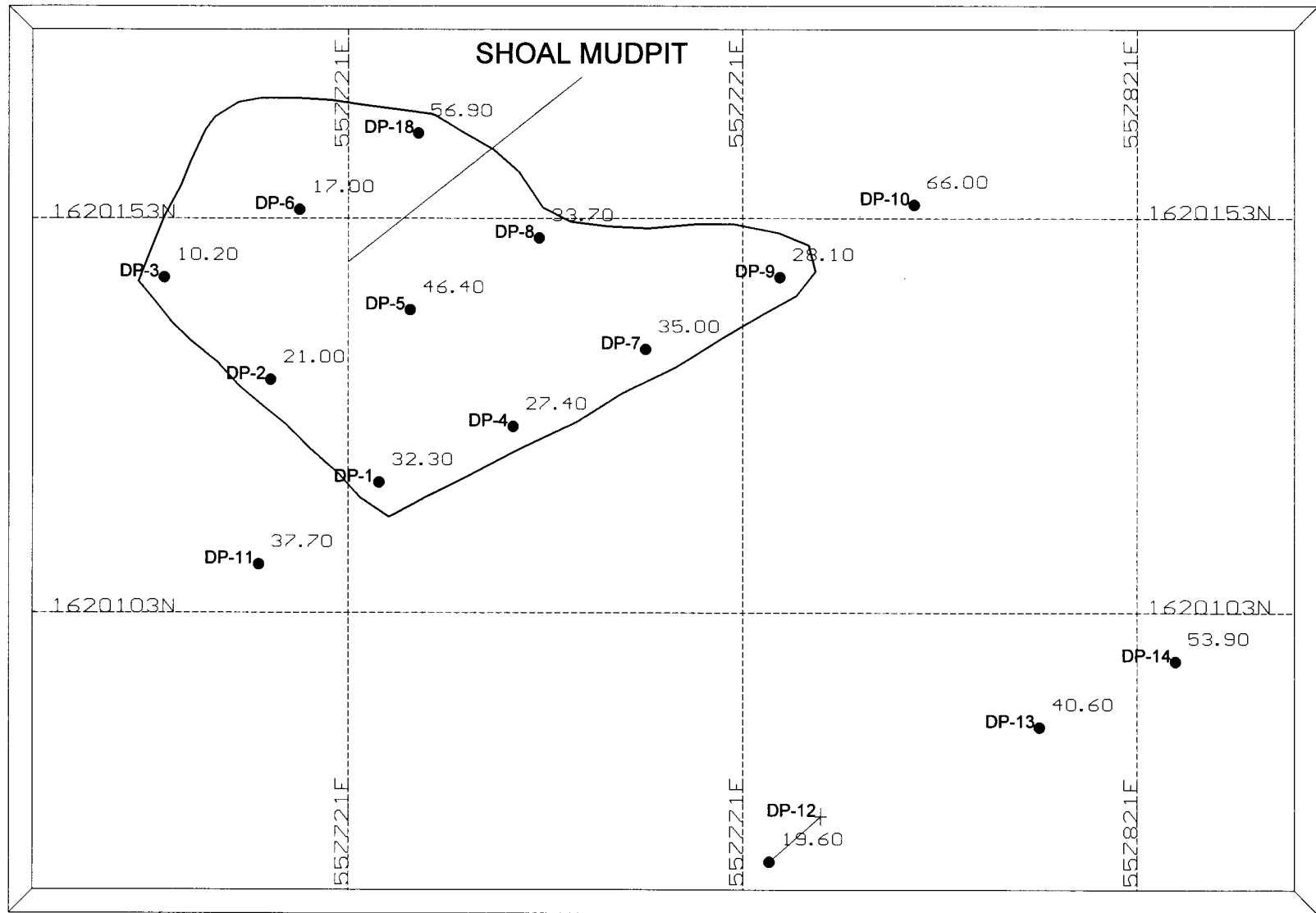
SHOAL PROJECT / MUDPIT

CHROMIUM > 1 MG/KG



Scale = 20 feet

Shoal Mud Pit Analytical Concentration Map of Gross Alpha  
Figure 2-12



SHOAL PROJECT / MUDPIT

GROSS ALPHA >1 PCI/G

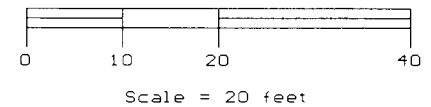
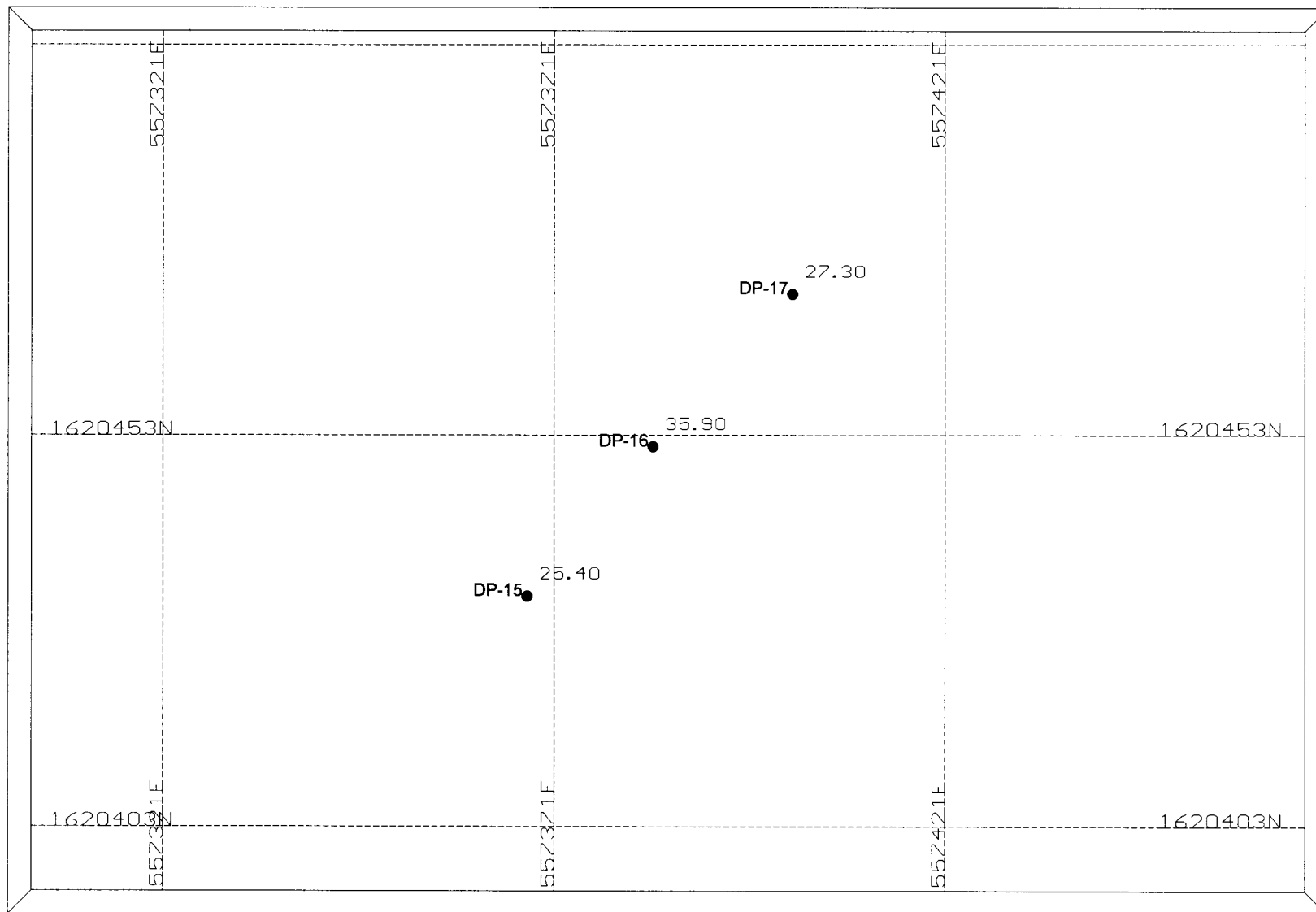


Figure 2-13  
Upgradient Analytical Concentration Map of Gross Alpha



SHOAL PROJECT/MUDPIT

GROSS ALPHA >1 PCI/G

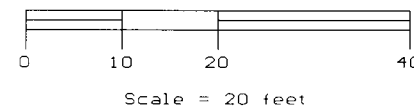
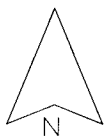
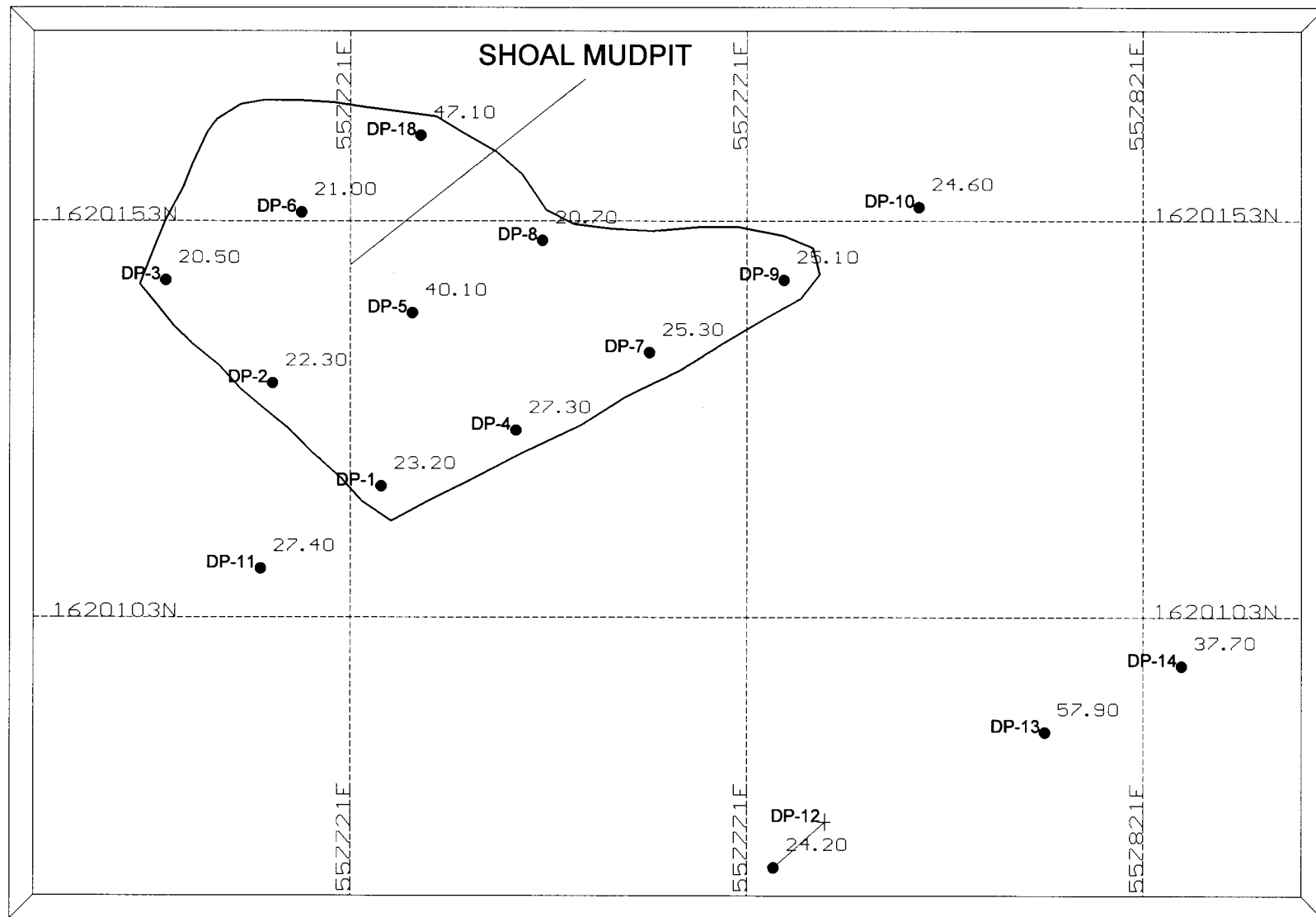
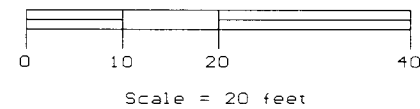


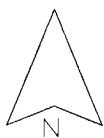
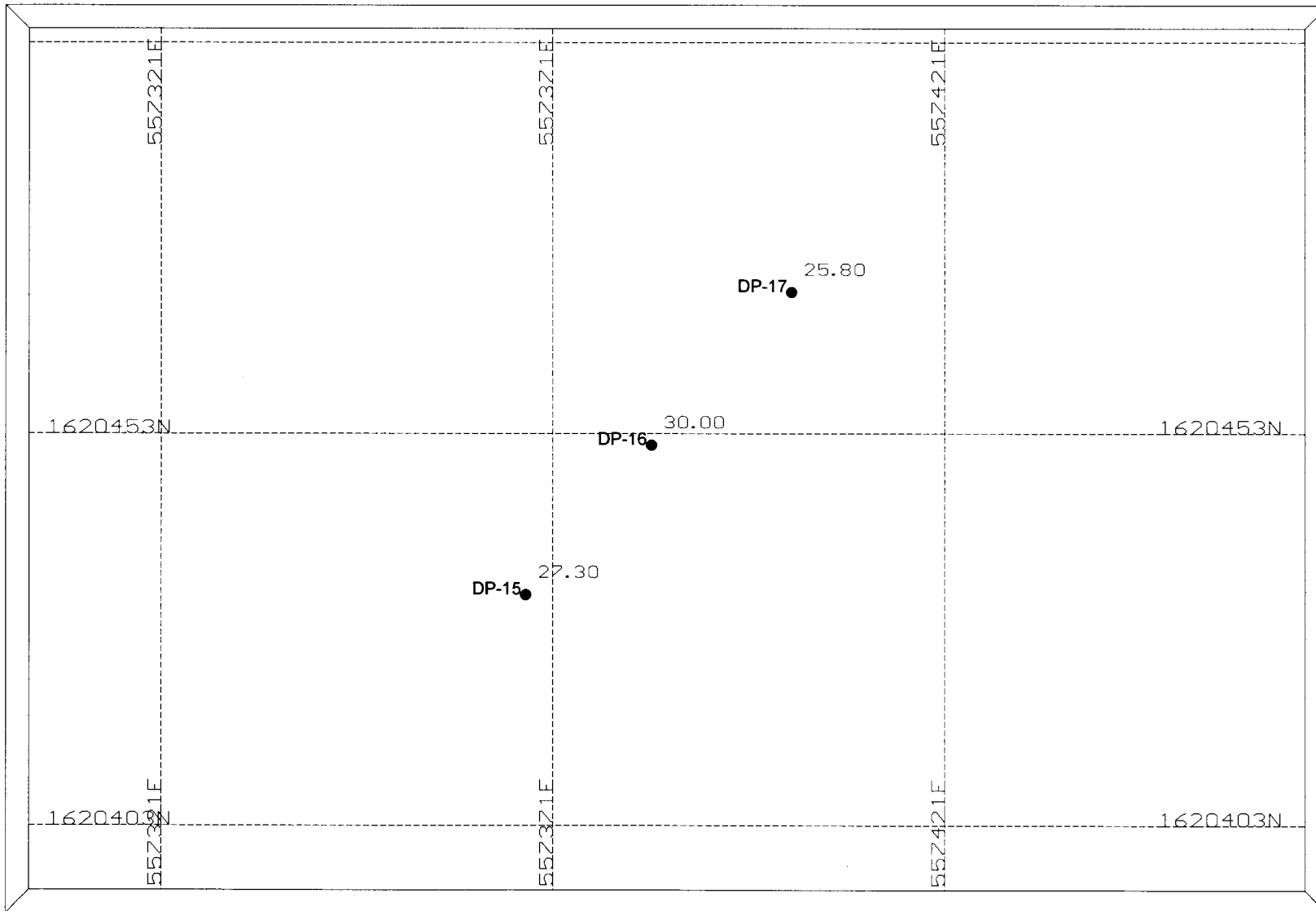
Figure 2-14  
Shoal Mud Pit Analytical Concentration Map of Gross Beta



SHOAL PROJECT/MUDPIT

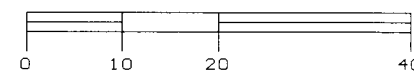
GROSS BETA > 1 PCI/G





SHOAL PROJECT/MUDPIT

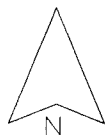
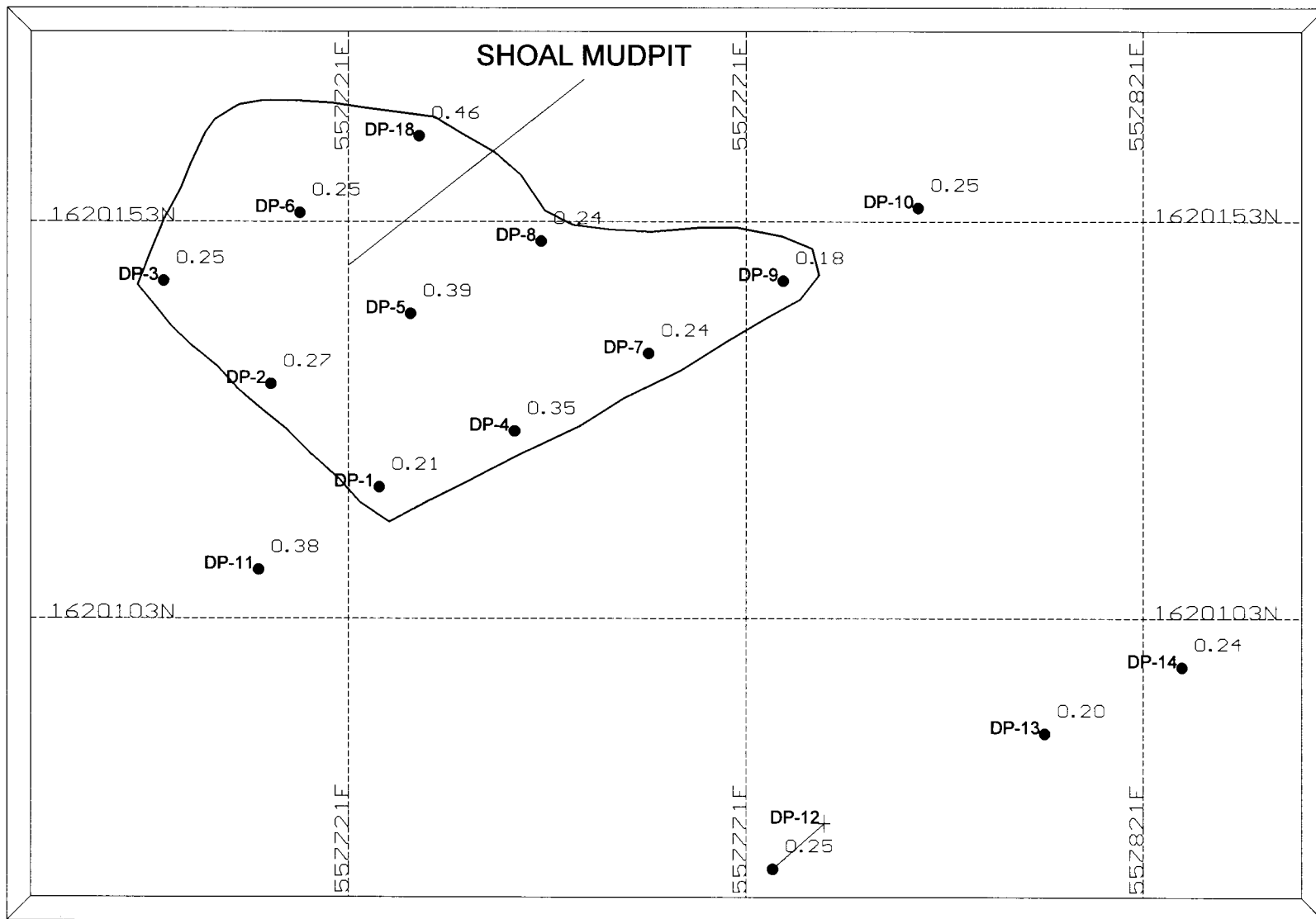
GROSS BETA > 1 PCI/G



Scale = 20 feet

Figure 2-15  
Upgradient Analytical Concentration Map of Gross Beta

Shoal Mud Pit Analytical Concentration Map of Cesium-137  
Figure 2-16



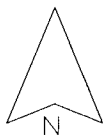
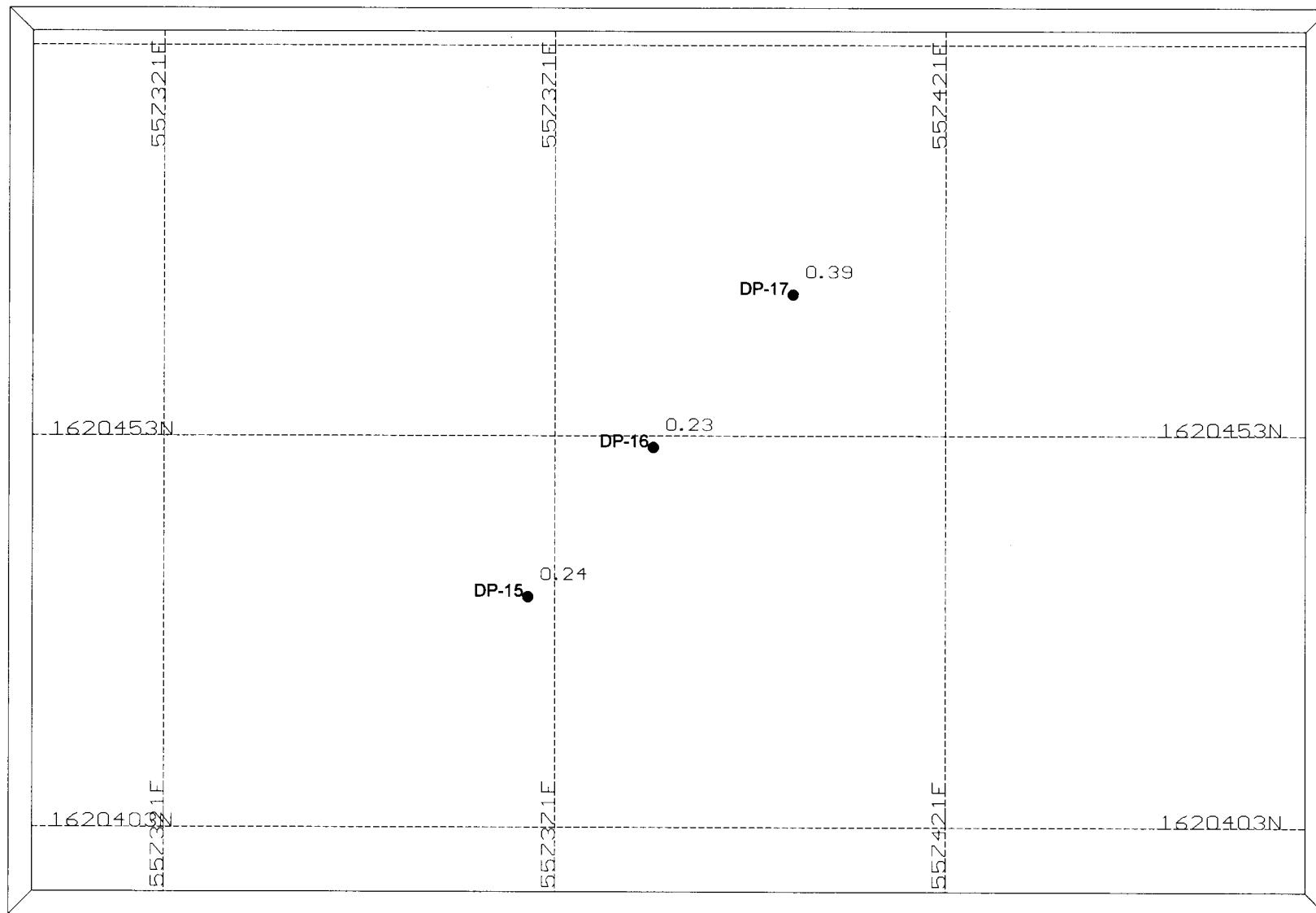
SHOAL PROJECT/MUDPIT

CESIUM137>0.10 PCI/G



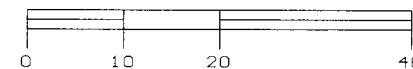
Scale = 20 feet

Figure 2-17  
Upgradient Analytical Concentration Map of Cesium-137



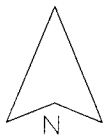
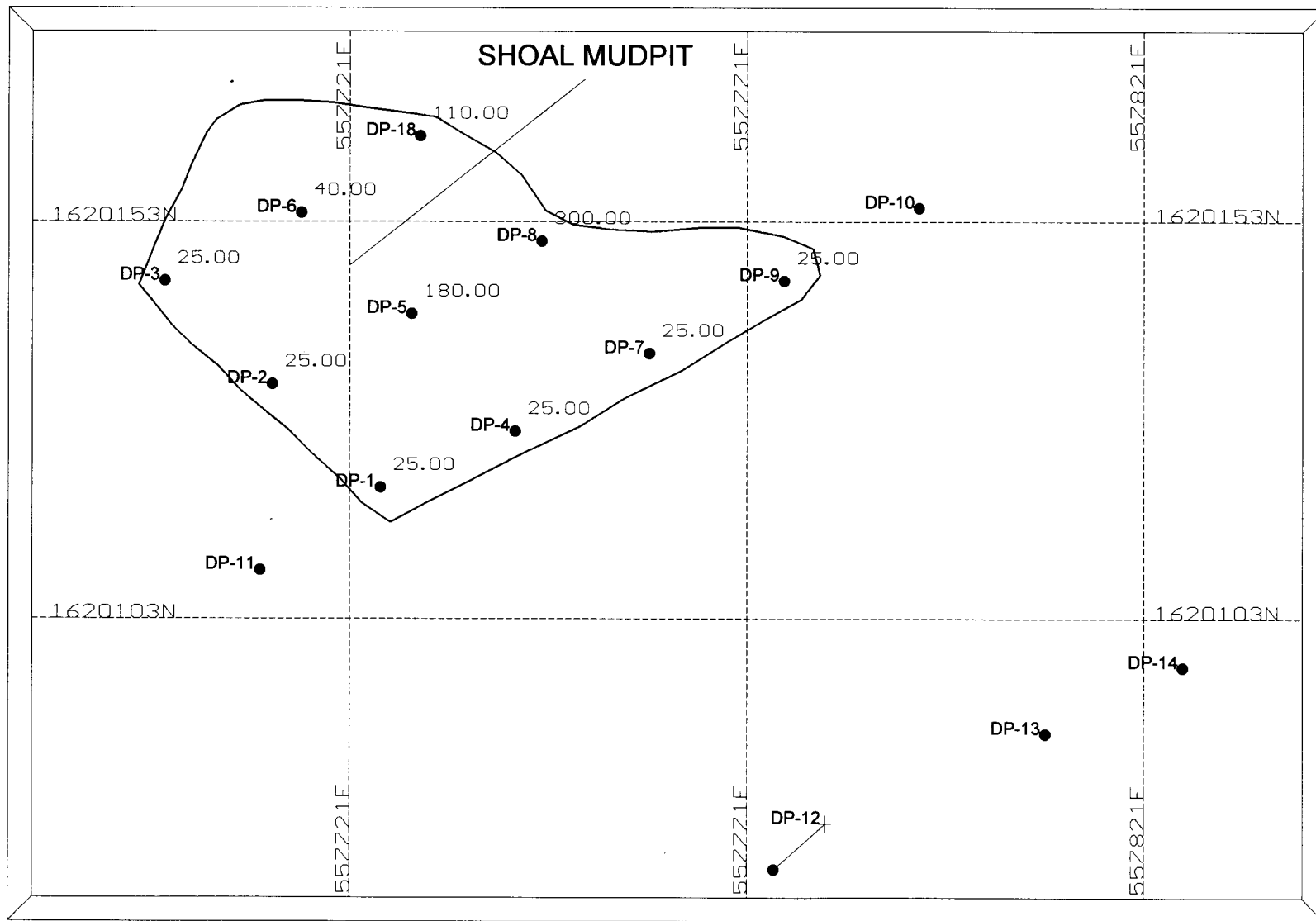
SHOAL PROJECT / MUDPIT

CESIUM137 > 0.10 PCI/G



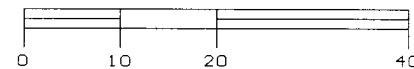
Scale = 20 feet

Figure 2-18  
Shoal Mud Pit Analytical Concentration Map of TPH Diesel



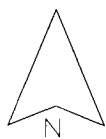
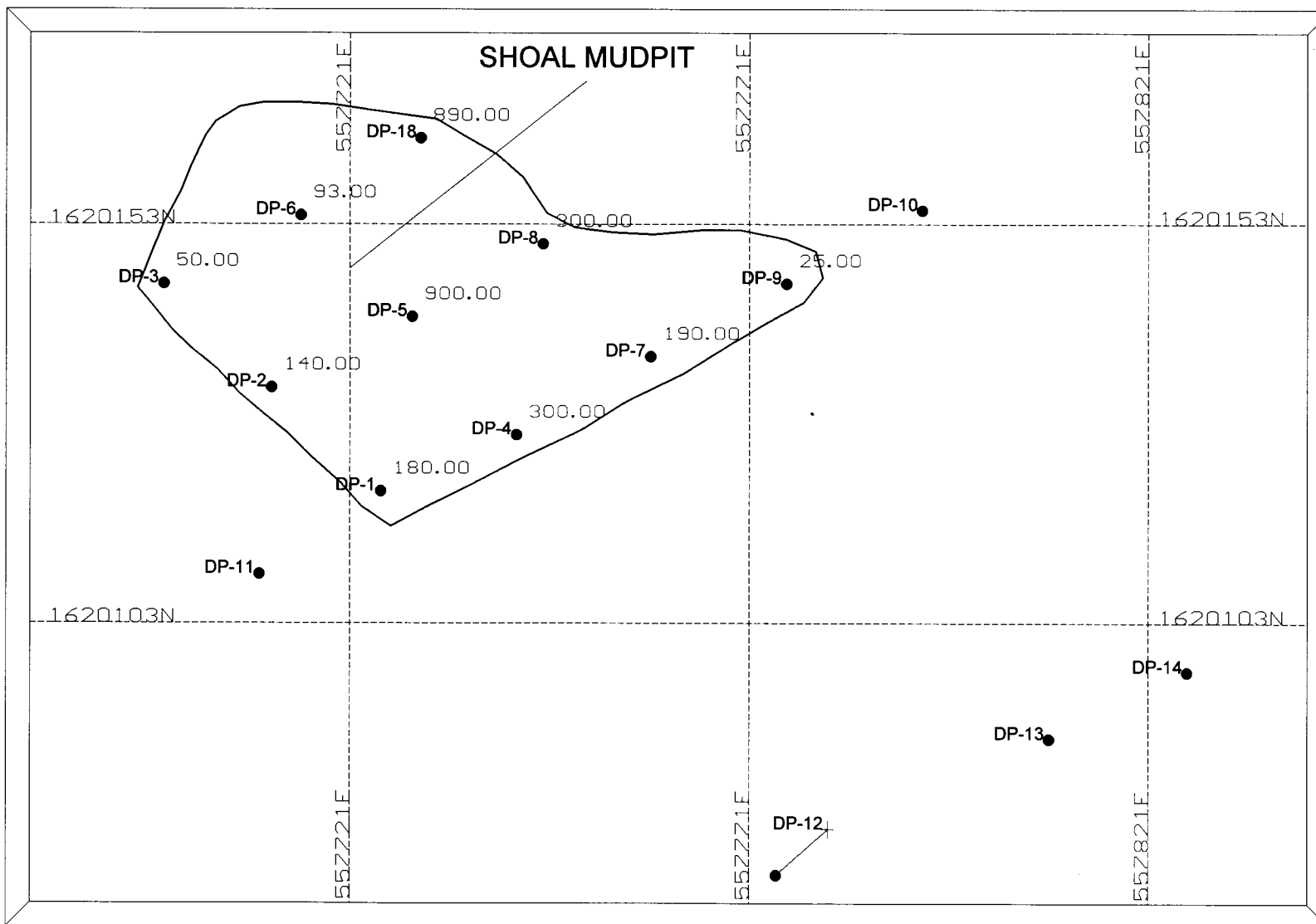
SHOAL PROJECT/MUDPIT

TPH DIESEL > 5 MG/KG



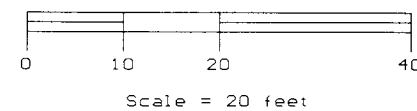
Scale = 20 feet

Figure 2-19  
Shoal Mud Pit Analytical Concentration Map of Waste Oil



SHOAL PROJECT/MUDPIT

WASTE OIL > 1 MG/KG



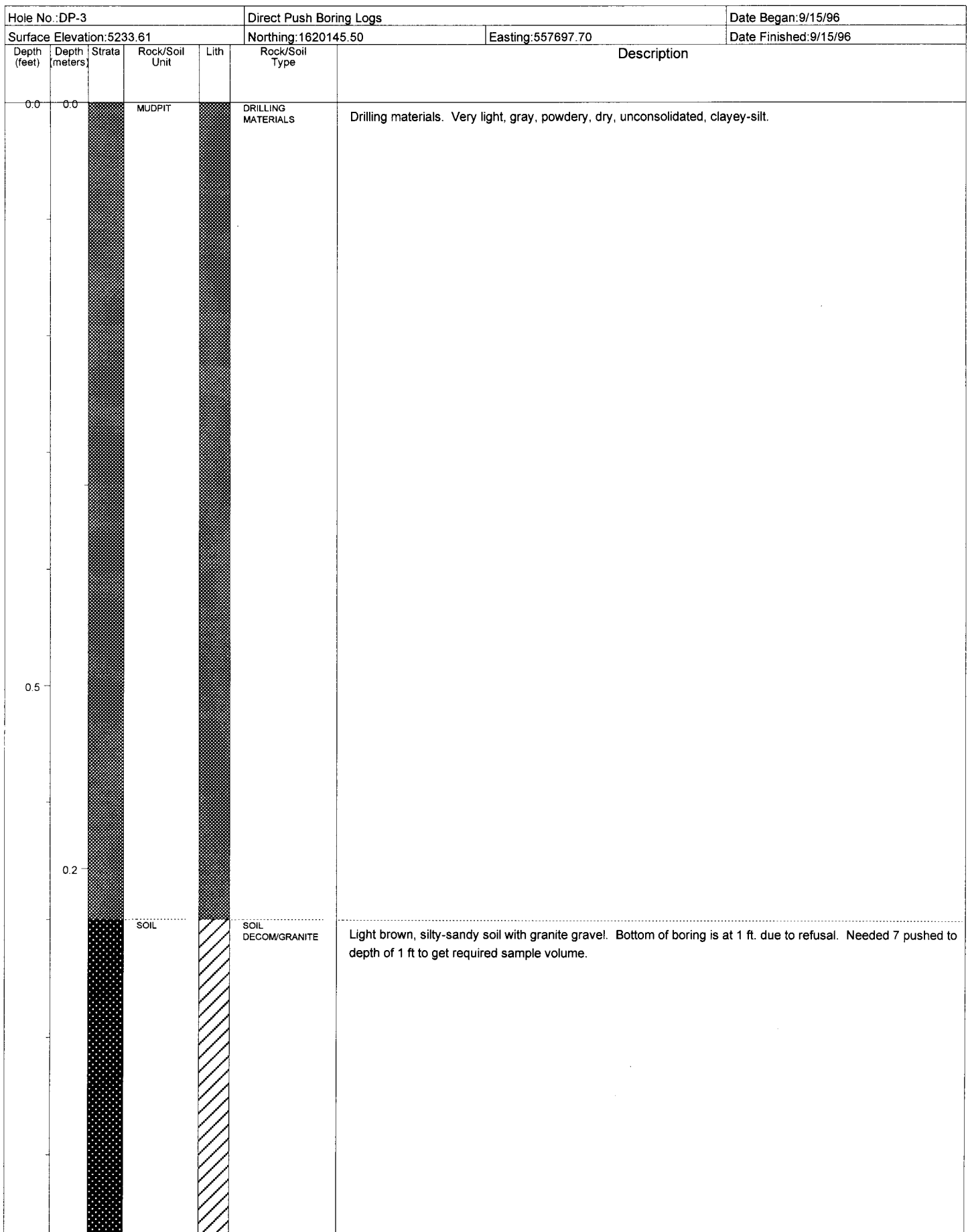
Hole No.: DP-1				Direct Push Boring Logs			Date Began: 9/15/96
Surface Elevation: 5231.52				Northing: 1620119.50		Easting: 557724.90	Date Finished: 9/15/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0	0.0		MUDPIT		DRILLING MATERIALS	Drilling materials. Very light gray, powdery, dusty, very fine grained, dry, unconsolidated, becoming coarser after 1.0 ft depth.	
1							
1							
2							
0.5			SOIL		SOIL	Weathered granite. Between 2 and 3 ft, getting a small amount of a black, smeary substance on the outside of the push rods. No reading on the PID, substance not seen in the soil.	
2					DECOM/GRANITE		
3							
3							
1.0							
4							
			BEDROCK		GRANITE	Pushed once from 0 to 4 ft. and twice from 0 to 3.5 ft. before refusal. Depth to granite is between 3.5 and 4.0 ft.	

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-20**  
**Soil Boring Log for DP-1**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

[illegible]



Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-22**  
**Soil Boring Log for DP-3**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

Hole No.: DP-4				Direct Push Boring Logs		Date Began: 9/15/96
Surface Elevation: 5231.16				Northing: 1620126.60	Easting: 557741.90	Date Finished: 9/15/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description
0.0	0.0		MUDPIT		DRILLING MATERIALS	Drilling materials. Very light gray, powdery, dusty, very fine grained, dry, unconsolidated.
0.5	0.2					
1.0	0.4					
1.5	0.6		SOIL		SOIL SILTY-SANDY	From 1.5 to 2: Silty light gray to light brown, dry soil, with some roots. After 2 ft becoming a grayish-brown, and coarser soil.
2.0	0.8					
2.5	1.0					
3.0	1.2					
3.5					SOIL DECOM/GRANITE	Weathered granite with a light brown soil matrix. Bottom of boring at 4.0 ft. due to refusal.
4.0						

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-23**  
**Soil Boring Log for DP-4**

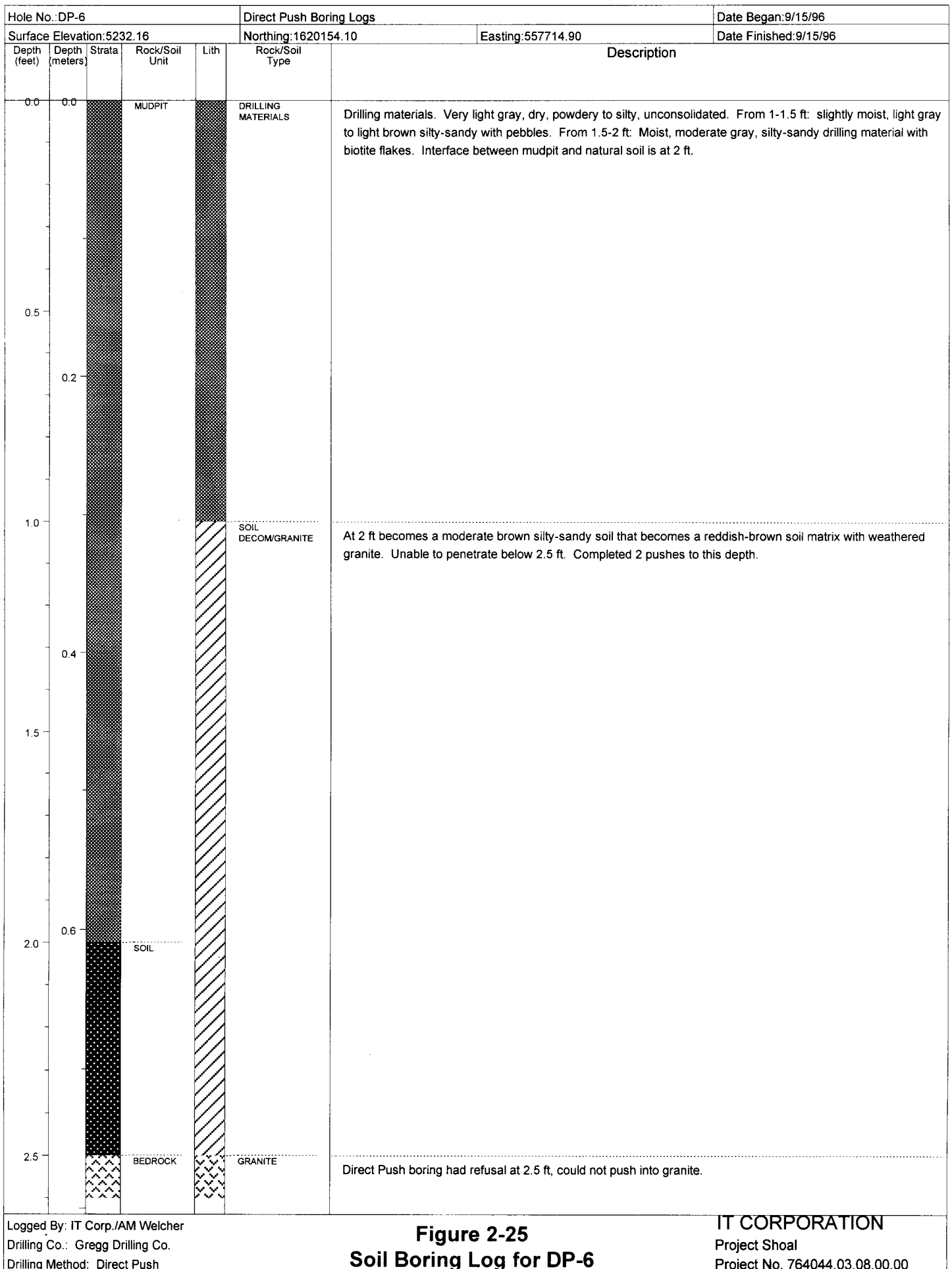
IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

Hole No.: DP-5					Direct Push Boring Logs		Date Began: 9/15/96
Surface Elevation: 5231.17					Northing: 1620141.40	Easting: 557728.80	Date Finished: 9/15/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0.0	0.0		MUDPIT		DRILLING MATERIALS	Drilling materials. Light-gray, fine grained, powdery, very dry, unconsolidated. At 0.5 ft, drilling materials starting to become moist, are darker gray, coarser, and more consolidated.	
0.5							
	0.2						
1.0							
	0.4						
1.5						Between the depths of 1.5 to 2.0 ft, there is a color change between borings in the 2x2 ft area. From moderate gray, fine grained, moist, with some hornblende, to orangeish-brown, fine grained, consolidated, to purplish-reddish brown, platy. Also found an angular gravel sized piece of rhyolite in this interval.	
	0.6						
2.0			SOIL		SOIL SILTY-SANDY	Moderate brown, silty soil.	
2.5					SOIL DECOM/GRANITE	Weathered granite with a reddish-brown soil matrix. Penetrated to 3 ft before refusal.	
	0.8						

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-24**  
**Soil Boring Log for DP-5**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00



Hole No.: DP-7					Direct Push Boring Logs		Date Began: 9/15/96
Surface Elevation: 5231.14					Northing: 1620136.40	Easting: 557758.70	Date Finished: 9/15/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0.0	0.0		MUDPIT		DRILLING MATERIALS	Drilling materials. From surface to 1 ft: light gray, powdery, dusty, dry, very fine grained, unconsolidated. Between 1 and 2 ft it appears that the drilling materials and soils alternate. Very light brownish-gray with some roots, to light gray, drilling material to light yellowish-brown silty soil.	
0.5							
	0.2						
1.0							
	0.4						
1.5							
	0.6		SOIL	SOIL SILTY-SANDY		Gray-brown to moderate brown silty-sandy soil at 2 ft, becoming a moderate yellowish-brown soil with biotite flakes and subangular granite towards 3 ft. Refusal at 3 ft, could not push deeper.	
2.0							
	0.8						
2.5							

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-26**  
**Soil Boring Log for DP-7**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

Hole No.: DP-8				Direct Push Boring Logs			Date Began: 9/6/96
Surface Elevation: 5230.98				Northing: 1620150.50		Easting: 557745.20	Date Finished: 9/6/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0.0	0.0		MUDPIT		DRILLING MATERIALS	Drilling materials. Light gray to white, powdery, dusty, very dry, some biotite flakes at 1 ft. Below 1 ft becoming more consolidated, and darker gray in sample sleeve.	
0.5							
0.2							
1.0							
0.4							
1.5							
0.6			BEDROCK		GRANITE	Very thin layer of the very fine grained, light brown soil. Can not push any further than 2 ft. The mud pit is essentially sitting on the granitic bedrock at this location. Direct Push boring had refusal at 2.0 ft, could not push into granite.	
Logged By: IT Corp./AM Welcher Drilling Co.: Gregg Drilling Co. Drilling Method: Direct Push				<b>Figure 2-27</b> <b>Soil Boring Log for DP-8</b>			IT CORPORATION Project Shoal Project No. 764044.03.08.00.00

Hole No.:DP-9					Direct Push Boring Logs		Date Began:9/15/96
Surface Elevation:5231.80					Northing:1620145.50		Easting:557775.70
					Date Finished:9/15/96		
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0.0	0.0		MUDPIT		DRILLING MATERIALS	Surface at DP-9 is the light gray drilling material. Light gray, fine grained, powdery, very dry. Drilling mud layer is very thin here.	
0.5	0.2		SOIL		SOIL SILTY-SANDY	Light-brownish gray with some organics, to light yellowish-brown to moderate yellowish-brown, silty soil, dry, becoming coarser and darker with depth.	
1.0							
	0.4						
1.5							
	0.6						
2.0							
	0.8						
2.5							
	1.0						
3.0							
	1.2				SOIL DECOM/GRANITE	Light brown, silty sand with angular granitic pebbles and weathered granite. Bottom of boring was at 4 ft, as this was a shallow sample. Depth to interface of decomposing granite and granite is unknown, and the interface is	
4.0						The bottom of the boring is at 4 ft. as this was a shallow sample and there was no refusal. The interface between the decomposing granite and the granite is unknown and the interface is interpreted.	
			BEDROCK		GRANITE	The bottom of the boring is at 4 ft. as this was a shallow sample and there was no refusal. The interface between the decomposing granite and the granite is unknown and the interface is interpreted.	
4.5	1.4						

Logged By: IT Corp./AM Welcher  
Drilling Co.: Gregg Drilling Co.  
Drilling Method: Direct Push

Figure 2-28  
Soil Boring Log for DP-9

IT CORPORATION  
Project Shoal  
Project No. 764044.03.08.00.00

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-28**  
**Soil Boring Log for DP-9**

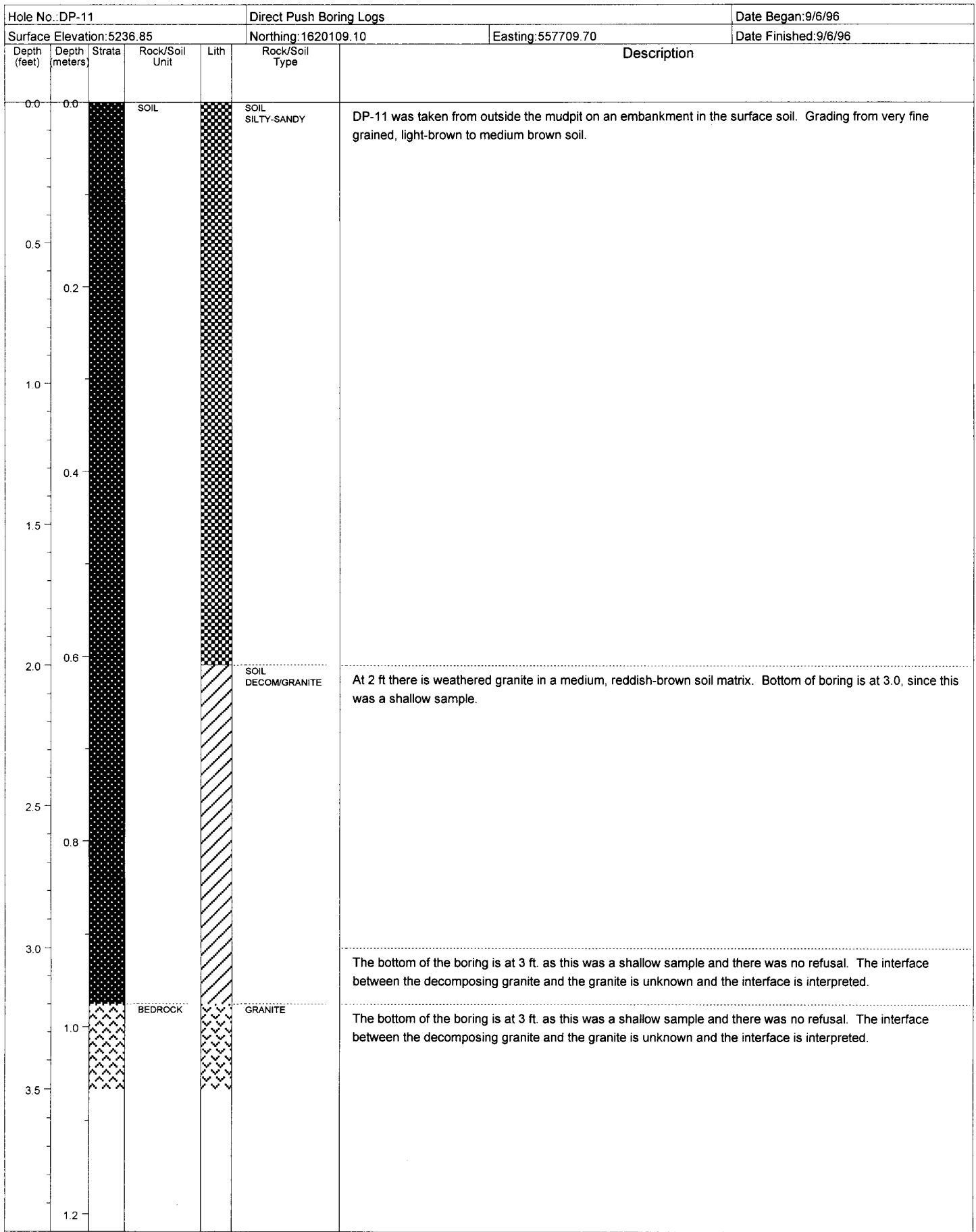
IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

Hole No.: DP-10			Direct Push Boring Logs			Date Began: 9/6/96
Surface Elevation: 5234.51			Northing: 1620154.70		Easting: 557792.70	Date Finished: 9/6/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description
0.0	0.0		SOIL		SOIL SILTY-SANDY	
0.5	0.2					
1.0						
1.5	0.4					
2.0	0.6					
2.5	0.8				SOIL DECOM/GRANITE	Grades from a moderate-brown, soil with biotite flakes at 2.5 ft. to a decomposing granite in a moderate brown soil matrix at 3 ft. Bottom of boring is at 3.0 ft, did not penetrate further as this was a shallow sample.
3.0	1.0					The bottom of the boring is at 3 ft. as this was a shallow sample and there was no refusal. The interface between the decomposing granite and the granite is unknown and the interface is interpreted.
3.5			BEDROCK		GRANITE	The bottom of the boring is at 3 ft. as this was a shallow sample and there was no refusal. The interface
1.2						

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-29**  
**Soil Boring Log for DP-10**

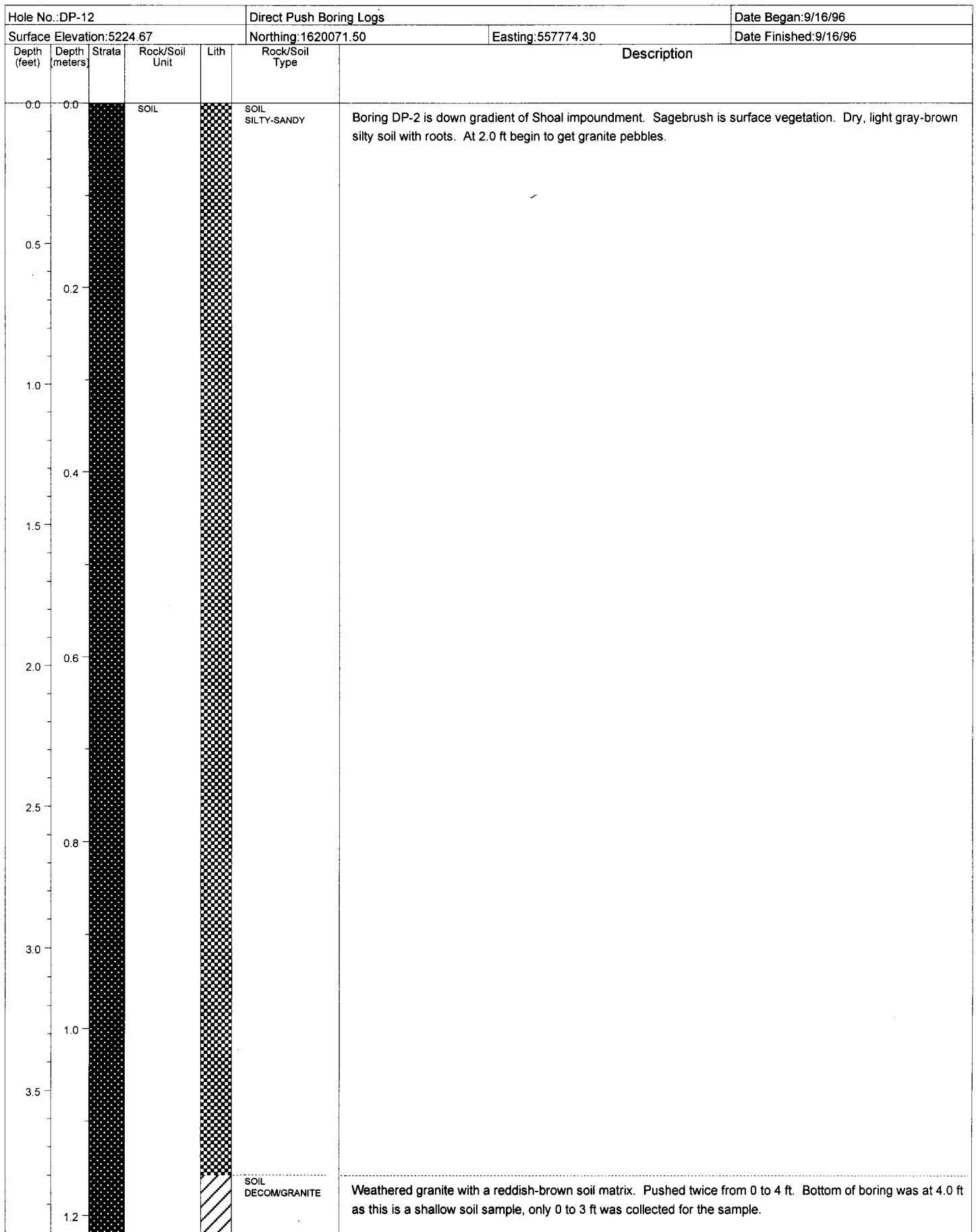
IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00



Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-30**  
**Soil Boring Log for DP-11**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00



Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-31**  
**Soil Boring Log for DP-12**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

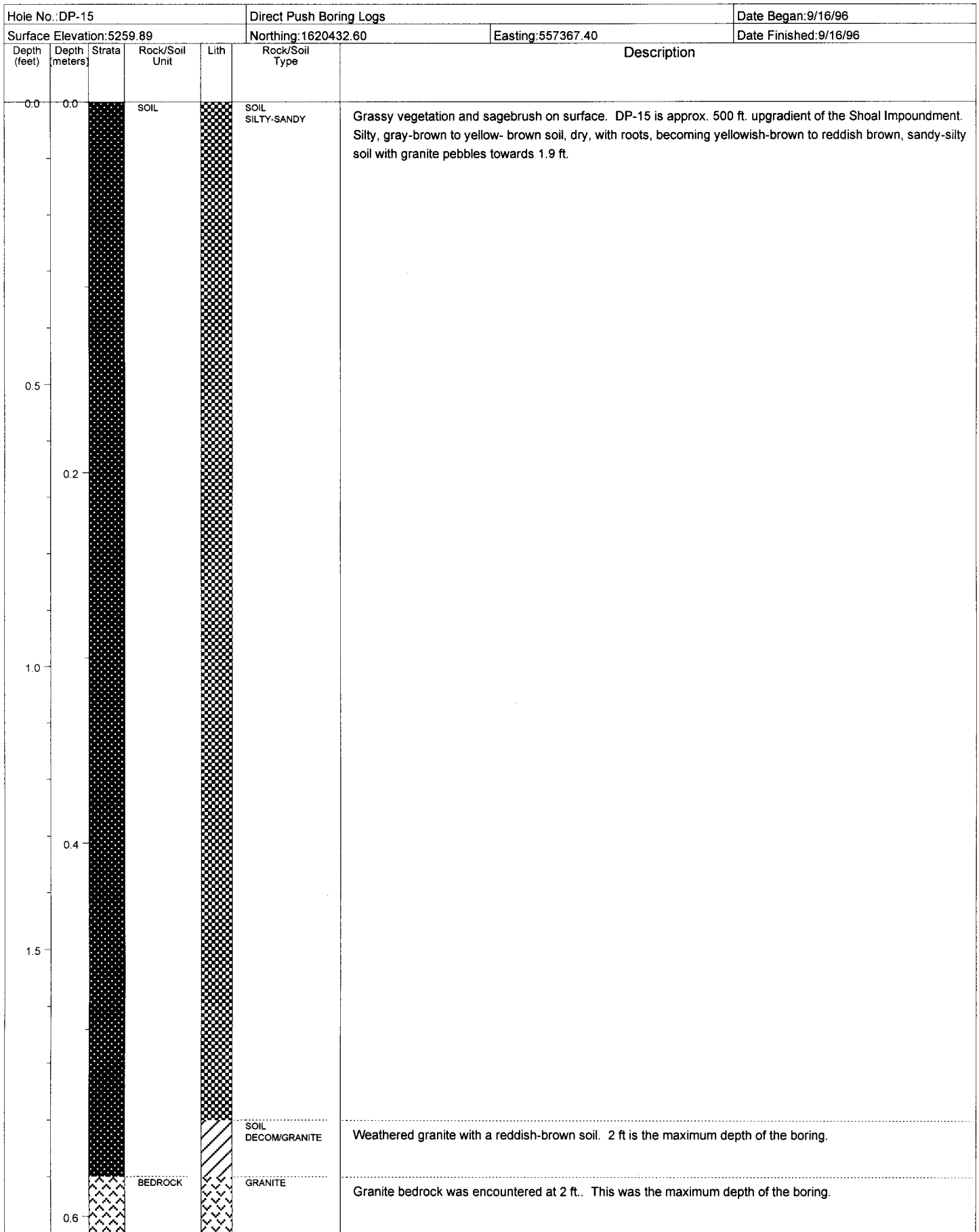
Hole No.: DP-13					Direct Push Boring Logs		Date Began: 9/16/96
Surface Elevation: 5224.16					Northing: 1620088.50	Easting: 557808.60	Date Finished: 9/16/96
Depth (feet)	Depth (meters)	Strata	Rock/Soil Unit	Lith	Rock/Soil Type	Description	
0.0	0.0		SOIL		SOIL SILTY-SANDY	DP-13 is down gradient from the Shoal Impoundment. Light yellowish-brown, silty to sandy soil, dry, becoming more coarse and gravelly towards 2.7 ft.	
0.5							
1.0							
1.5							
2.0							
2.5							
	0.8				SOIL DECOM/GRANITE	Weathered granite with a light brown soil matrix. Gregg drilling pushed twice from 0 to 3 ft, could not push deeper than 3 ft due to refusal.	

Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-32**  
**Soil Boring Log for DP-13**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

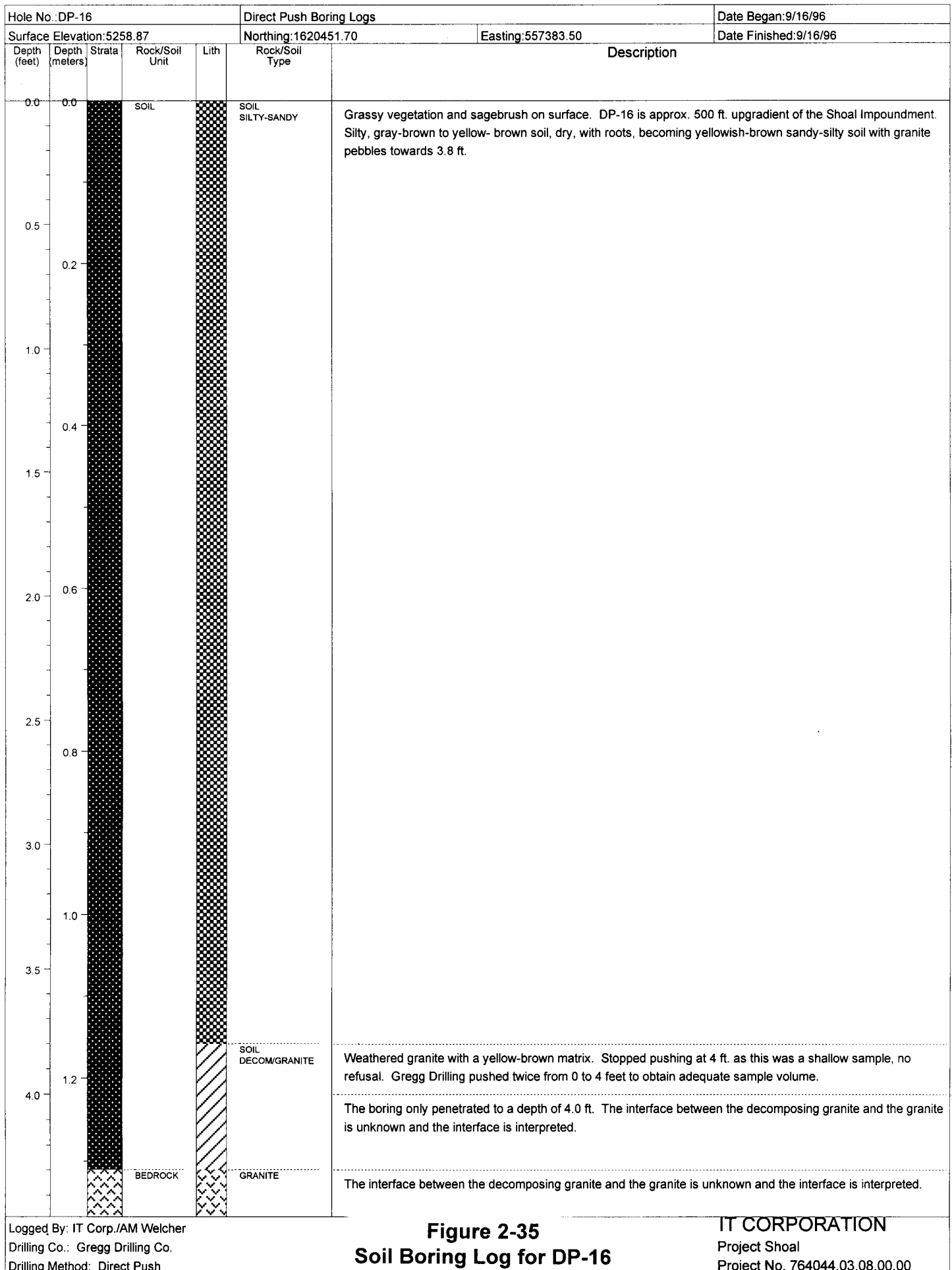


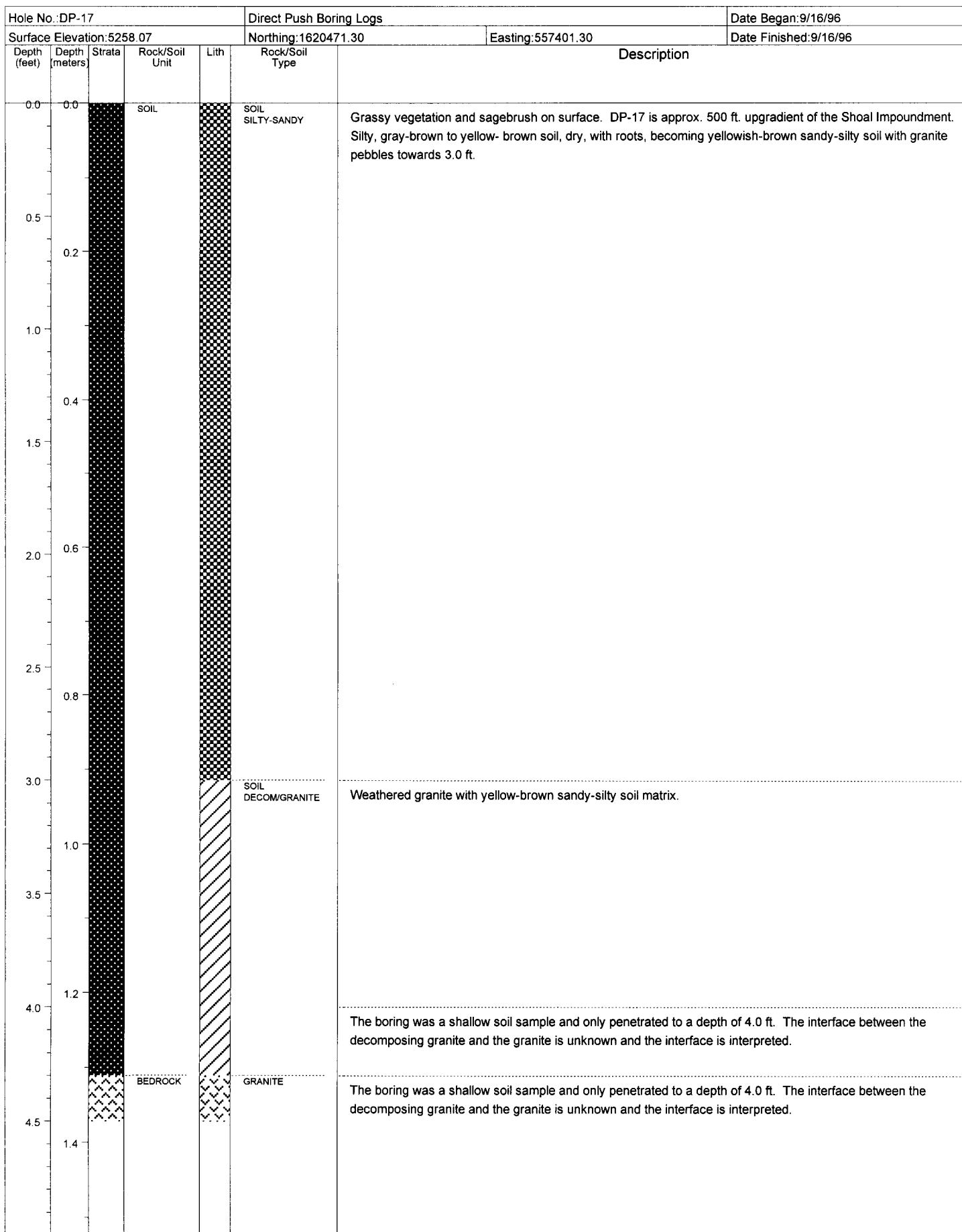


Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-34**  
**Soil Boring Log for DP-15**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00

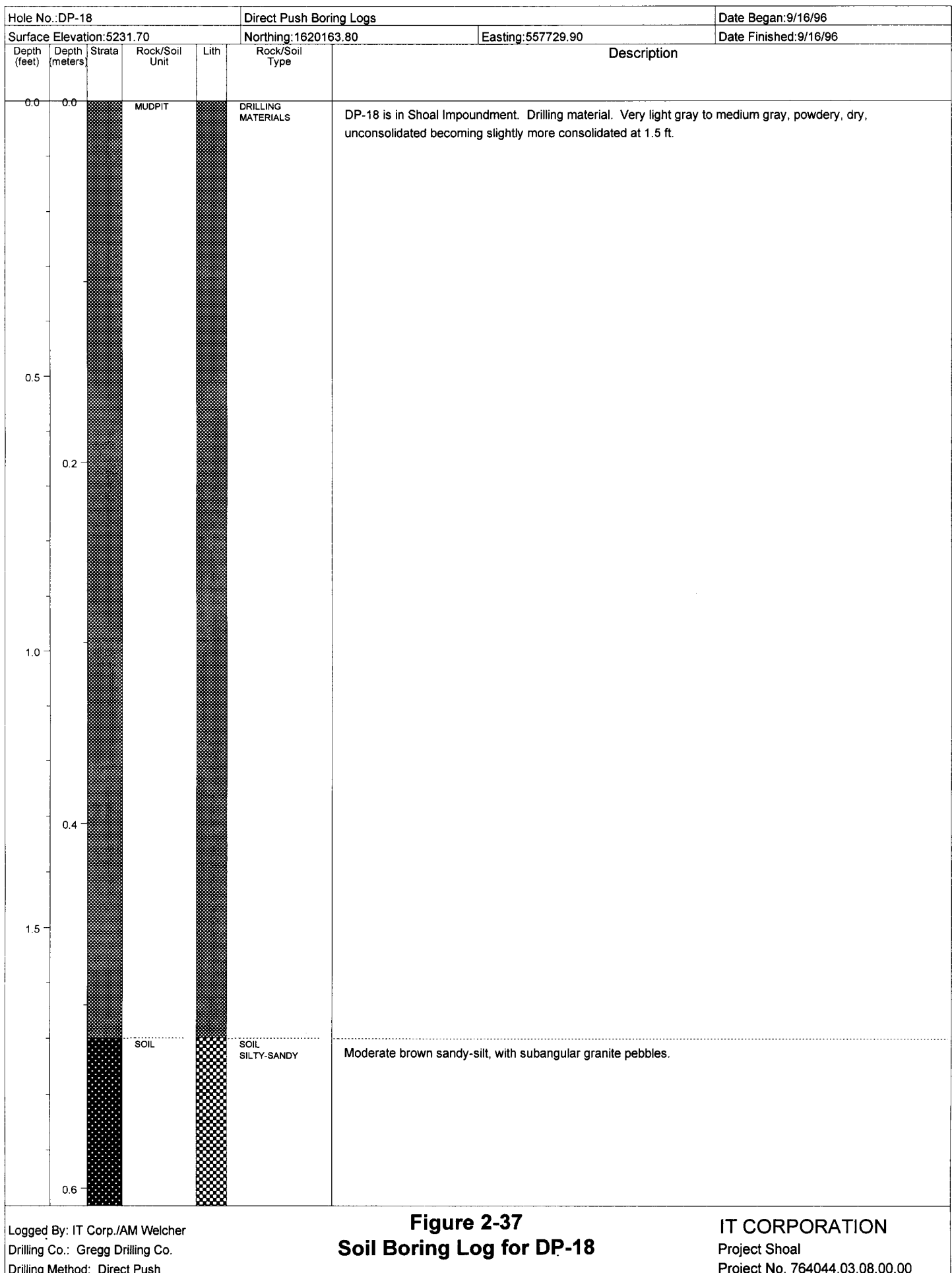




Logged By: IT Corp./AM Welcher  
 Drilling Co.: Gregg Drilling Co.  
 Drilling Method: Direct Push

**Figure 2-36**  
**Soil Boring Log for DP-17**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.08.00.00



**Table 2-1**  
**Summary of Shoal Direct Push Samples**

Sample Number	Date Collected	Location	Shallow/Deep Sample	Depth (meters)	Depth (feet)	COC <sup>a</sup> Number	Comments
PSS00001	9/15/96	DP-1	Shallow	0 - 0.61	0 - 2	519809	Shallow Composite Sample inside Mud Pit
PSS00002	9/15/96	DP-1	Deep	0.61 - 1.22	2 - 4	519809	Deep Composite Sample inside Mud Pit
PSS00003	9/11/96	DP-1	Quality Control (QC)	N/A <sup>b</sup>	N/A	485538	Field Blank
PSS00004	9/11/96	DP-1	QC	N/A	N/A	485538	Equipment Rinsate
PSS00005	9/15/96	DP-2	Shallow	0 - 0.31	0 - 1	519809	Waste Management Composite
PSS00006	9/15/96	DP-2	Shallow	0 - 0.31	0 - 1	519809	Duplicate of Sample PSS00005
PSS00007	9/15/96	DP-3	Shallow	0 - 0.31	0 - 1	519809	Shallow Composite Sample inside Mud Pit
PSS00008	9/15/96	DP-4	Shallow	0 - 0.61	0 - 2	519809	Shallow Composite Sample inside Mud Pit
PSS00009	9/15/96	DP-4	Deep	0.61 - 1.22	2 - 4	519809	Deep Composite Sample inside Mud Pit
PSS00010	9/15/96	DP-5	Shallow	0 - 0.61	0 - 2	519809	Waste Management Composite...Laboratory QC
PSS00011	9/15/96	DP-5	Deep	0.61 - .091	2 - 3	519809	Deep Composite Sample inside Mud Pit
PSS00012	N/A	DP-5	N/A	N/A	N/A	N/A	Not Collected...Unique number not needed for Lab QC
PSS00013	9/15/96	DP-6	Shallow	0 - 0.76	0 - 2.5	519809	Shallow Composite Sample inside Mud Pit
PSS00014	9/15/96	DP-7	Shallow	0 - 0.61	0 - 2	519809	Shallow Composite Sample inside Mud Pit
PSS00015	9/6/96	DP-8	Shallow	0 - 0.61	0 - 2	404697	Waste Management Composite
PSS00016	9/15/96	DP-9	Shallow	0 - 0.91	0 - 3	519809	Shallow Composite Sample inside Mud Pit
PSS00017	9/6/96	DP-10	Shallow	0 - 0.91	0 - 3	404697	Shallow Composite Sample adjacent to Mud Pit
PSS00018	9/6/96	DP-11	Shallow	0 - 0.91	0 - 3	404697	Shallow Composite Sample adjacent to Mud Pit
PSS00019	9/16/96	DP-12	Shallow	0 - 0.91	0 - 3	519801	Shallow Composite Sample Downgradient from Mud Pit
PSS00020	9/16/96	DP-13	Shallow	0 - 0.91	0 - 3	519801	Shallow Composite Sample Downgradient from Mud Pit
PSS00021	9/16/96	DP-14	Shallow	0 - 0.31	0 - 1	519801	Shallow Composite Sample Downgradient from Mud Pit
PSS00022	9/16/96	DP-15	Shallow	0 - 0.61	0 - 2	519801	Shallow Composite Upgradient from Mud Pit...Lab QC
PSS00023	9/16/96	DP-15	Shallow	0 - 0.61	0 - 2	519801	Duplicate of Sample PSS00022
PSS00024	9/15/96	DP-7	Deep	0.61 - 0.91	2 - 3	519809	Deep Composite Sample inside Mud Pit
PSS00025	N/A	DP-8	N/A	N/A	N/A	N/A	Deep Composite Sample not collected due to refusal
PSS00026	9/16/96	DP-16	Shallow	0 - 0.91	0 - 3	519801	Shallow Composite Sample upgradient from Mud Pit
PSS00027	9/16/96	DP-17	Shallow	0 - 0.91	0 - 3	519801	Shallow Composite Sample upgradient from Mud Pit
PSS00028	9/15/96	DP-18	Shallow	0 - 0.61	0 - 2	519809	Shallow Composite Sample inside Mud Pit
PSS00029	9/15/96	DP-18	Deep	0.61 - 0.70	2 - 2.3	519809	Deep Composite Sample inside Mud Pit
PSS00030	9/16/96	DP-15	QC	N/A	N/A	519805	Field Blank
PSS00031	9/16/96	DP-15	QC	N/A	N/A	519807	Equipment Rinsate
PST00001	9/11/96	DP-1	QC	N/A	N/A	485538	Trip Blank, Quanterra Lab, St. Louis
PST00002	9/6/96	DP-8	QC	N/A	N/A	404697	Trip Blank, Quanterra Lab, St. Louis
PST00003	9/15/96	DP-5	QC	N/A	N/A	519809	Trip Blank, Quanterra Lab, St. Louis
PST00004	9/16/96	DP-15	QC	N/A	N/A	519807	Trip Blank, Quanterra Lab, St. Louis

<sup>a</sup>Chain of Custody

<sup>b</sup>Not Analyzed

**Table 2-2**  
**Shoal Mud Pit Analytical Data**  
 (Page 1 of 3)

Sample Location	Sample #	Sample Date	Matrix	Arsenic mg/L <sup>a</sup>	Barium mg/L	Barium mg/kg <sup>b</sup>	Cadmium mg/L	Chromium mg/L	Chromium mg/kg	Lead mg/L	Mercury mg/L	Selenium mg/L
DP-1	PSS00001	9/15/96	Soil	N/A <sup>c</sup>	N/A	234	N/A	N/A	7.7	N/A	N/A	N/A
DP-1	PSS00002	9/15/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-2	PSS00005	9/15/96	Soil	0.02 (ND) <sup>d</sup>	1.2	N/A	0.005 (ND)	0.042	N/A	0.025	0.0001 (ND)	0.028 (ND)
DP-2	PSS00006	9/15/96	Soil	0.02 (ND)	1.2	N/A	0.005 (ND)	0.046	N/A	0.030	0.0001 (ND)	0.028 (ND)
DP-3	PSS00007	9/15/96	Soil	N/A	N/A	206	N/A	N/A	12.6	N/A	N/A	N/A
DP-4	PSS00008	9/15/96	Soil	N/A	N/A	437	N/A	N/A	10.9	N/A	N/A	N/A
DP-4	PSS00009	9/15/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-5	PSS00010	9/15/96	Soil	0.023	2.7	N/A	0.0078	0.092	N/A	0.014 (ND)	0.0001 (ND)	0.028 (ND)
DP-5	PSS00011	9/15/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-6	PSS00013	9/15/96	Soil	N/A	N/A	240	N/A	N/A	9.7	N/A	N/A	N/A
DP-7	PSS00014	9/15/96	Soil	N/A	N/A	710	N/A	N/A	10.7	N/A	N/A	N/A
DP-7	PSS00024	9/15/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-8	PSS00015	9/6/96	Soil	0.26 (ND)	0.95	N/A	0.013 (ND)	0.11	N/A	0.17(ND)	0.0001 (ND)	0.21(ND)
DP-9	PSS00016	9/15/96	Soil	N/A	N/A	235	N/A	N/A	7.9	N/A	N/A	N/A
DP-10	PSS00017	9/6/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-11	PSS00018	9/6/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-12	PSS00019	9/16/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-13	PSS00020	9/16/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-14	PSS00021	9/16/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DP-15	PSS00022	9/16/96	Soil	N/A	N/A	104	N/A	N/A	7.4	N/A	N/A	N/A
DP-15	PSS00023	9/16/96	Soil	N/A	N/A	84.2	N/A	N/A	6.4	N/A	N/A	N/A
DP-16	PSS00026	9/16/96	Soil	N/A	N/A	141	N/A	N/A	10.2	N/A	N/A	N/A
DP-17	PSS00027	9/16/96	Soil	N/A	N/A	103	N/A	N/A	10.2	N/A	N/A	N/A
DP-18	PSS00028	9/15/96	Soil	N/A	N/A	292	N/A	N/A	18.5	N/A	N/A	N/A
DP-18	PSS00029	9/15/96	Soil	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Milligram(s) per kilogram

<sup>c</sup>Not Analyzed

<sup>d</sup>Reported value is below detection limit.

<sup>e</sup>PicoCurie(s) per gram

<sup>f</sup>Not detected

**Table 2-2**  
**Shoal Mud Pit Analytical Data**  
 (Page 2 of 3)

Sample Location	Sample #	Sample Date	Matrix	Silver mg/L	Gross Alpha pCi/g <sup>e</sup>	Gross Beta pCi/g	Bismuth-214 pCi/g	Cesium-137 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Potassium-40 pCi/g
DP-1	PSS00001	9/15/96	Soil	N/A	20.1	18.9	ND <sup>f</sup>	0.21 (ND)	0.88	1	25.3
DP-1	PSS00002	9/15/96	Soil	N/A	32.3	23.2	ND	0.19 (ND)	1.2	0.68	24.5
DP-2	PSS00005	9/15/96	Soil	0.01 (ND)	10.6	22.3	ND	0.27 (ND)	0.96	1.22	18.5
DP-2	PSS00006	9/15/96	Soil	0.01 (ND)	21.0	20.8	ND	0.23 (ND)	0.78	0.92	23.2
DP-3	PSS00007	9/15/96	Soil	N/A	10.2	20.5	ND	0.25 (ND)	1.23	0.8	26.8
DP-4	PSS00008	9/15/96	Soil	N/A	23.8	20.7	ND	0.35 (ND)	1.23	0.99	16.4
DP-4	PSS00009	9/15/96	Soil	N/A	27.4	27.3	ND	0.22 (ND)	1.48	1.21	25.1
DP-5	PSS00010	9/15/96	Soil	0.01 (ND)	27.7	18.5	ND	0.22 (ND)	1.01	1.31	15.5
DP-5	PSS00011	9/15/96	Soil	N/A	46.4	40.1	1.14	0.39 (ND)	1.86	1.06	16.9
DP-6	PSS00013	9/15/96	Soil	N/A	17.0	21.0	ND	0.25 (ND)	1.11	0.83	23.8
DP-7	PSS00014	9/15/96	Soil	N/A	30.7	24.0	0.67	0.24 (ND)	0.94	0.85	24.7
DP-7	PSS00024	9/15/96	Soil	N/A	35.0	25.3	0.99	0.21 (ND)	1.43	0.99	23.7
DP-8	PSS00015	9/6/96	Soil	0.016 (ND)	33.7	20.7	ND	0.24 (ND)	0.98	ND	21.8
DP-9	PSS00016	9/15/96	Soil	N/A	28.1	25.1	ND	0.18 (ND)	1.41	1.09	24.8
DP-10	PSS00017	9/6/96	Soil	N/A	66.0	24.6	0.68	0.25 (ND)	0.5	0.87	27.2
DP-11	PSS00018	9/6/96	Soil	N/A	37.7	27.4	ND	0.38 (ND)	2.2	ND	22.1
DP-12	PSS00019	9/16/96	Soil	N/A	19.6	24.2	ND	0.25 (ND)	1.12	1.03	24.8
DP-13	PSS00020	9/16/96	Soil	N/A	40.6	57.9	1.26	0.20 (ND)	1.34	1.12	27.7
DP-14	PSS00021	9/16/96	Soil	N/A	53.9	37.7	1.33	0.24 (ND)	2.04	1.11	20.7
DP-15	PSS00022	9/16/96	Soil	N/A	23.9	27.1	1.03	0.24 (ND)	1.01	0.95	23.2
DP-15	PSS00023	9/16/96	Soil	N/A	25.4	27.3	1.36	0.23 (ND)	0.85	0.93	25.4
DP-16	PSS00026	9/16/96	Soil	N/A	35.9	30.0	0.82	0.23 (ND)	1.04	0.83	21.2
DP-17	PSS00027	9/16/96	Soil	N/A	27.3	25.8	ND	0.39 (ND)	ND	ND	17
DP-18	PSS00028	9/15/96	Soil	N/A	15.3	18.5	ND	0.46 (ND)	ND	1.75	17.1
DP-18	PSS00029	9/15/96	Soil	N/A	56.9	47.1	ND	0.24 (ND)	1.17	0.91	18.7

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Milligram(s) per kilogram

<sup>c</sup>Not Analyzed

<sup>d</sup>Reported value is below detection limit.

<sup>e</sup>PicoCurie(s) per gram

<sup>f</sup>Not detected

**Table 2-2**  
**Shoal Mud Pit Analytical Data**  
 (Page 3 of 3)

Sample Location	Sample #	Sample Date	Matrix	Radium-226 pCi/g	Radium-228 pCi/g	Thallium-208 pCi/g	Thorium-234 pCi/g	Tritium pCi/g	Diesel mg/kg	Waste Oil mg/kg
DP-1	PSS00001	9/15/96	Soil	ND	ND	ND	ND	0.005	25 (ND)	180
DP-1	PSS00002	9/15/96	Soil	3.11	ND	0.48	ND	0.0008	N/A	N/A
DP-2	PSS00005	9/15/96	Soil	ND	ND	0.31	ND	0.006	25 (ND)	130
DP-2	PSS00006	9/15/96	Soil	ND	1.03	0.3	ND	0.005	25 (ND)	140
DP-3	PSS00007	9/15/96	Soil	ND	ND	0.72	ND	-0.006	25 (ND)	50
DP-4	PSS00008	9/15/96	Soil	ND	ND	0.34	ND	-0.002	25 (ND)	300
DP-4	PSS00009	9/15/96	Soil	ND	ND	0.48	ND	0.005	N/A	N/A
DP-5	PSS00010	9/15/96	Soil	5.23	1.41	0.35	ND	0.076	180	900
DP-5	PSS00011	9/15/96	Soil	ND	ND	ND	ND	0.01	N/A	N/A
DP-6	PSS00013	9/15/96	Soil	3.75	1.53	0.44	ND	0.003	40	93
DP-7	PSS00014	9/15/96	Soil	ND	ND	0.32	1.94	0.003	25 (ND)	190
DP-7	PSS00024	9/15/96	Soil	ND	ND	0.48	ND	0.002	N/A	N/A
DP-8	PSS00015	9/6/96	Soil	ND	ND	0.37	ND	0.011	300 (ND)	300 (ND)
DP-9	PSS00016	9/15/96	Soil	ND	1.59	0.72	ND	-0.002	25 (ND)	25 (ND)
DP-10	PSS00017	9/6/96	Soil	ND	ND	0.34	ND	-0.004	N/A	N/A
DP-11	PSS00018	9/6/96	Soil	ND	ND	ND	ND	0.013	N/A	N/A
DP-12	PSS00019	9/16/96	Soil	5.78	ND	0.36	ND	-0.003	N/A	N/A
DP-13	PSS00020	9/16/96	Soil	ND	1.76	0.57	ND	-0.009	N/A	N/A
DP-14	PSS00021	9/16/96	Soil	ND	ND	0.39	ND	-0.005	N/A	N/A
DP-15	PSS00022	9/16/96	Soil	2.84	1.23	0.36	ND	ND	N/A	N/A
DP-15	PSS00023	9/16/96	Soil	ND	ND	0.42	ND	ND	N/A	N/A
DP-16	PSS00026	9/16/96	Soil	3.43	ND	0.31	1.87	ND	N/A	N/A
DP-17	PSS00027	9/16/96	Soil	ND	ND	0.74	ND	ND	N/A	N/A
DP-18	PSS00028	9/15/96	Soil	ND	ND	1.06	ND	-0.003	110	890
DP-18	PSS00029	9/15/96	Soil	ND	ND	0.37	ND	0.005	N/A	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Milligram(s) per kilogram

<sup>c</sup>Not Analyzed

<sup>d</sup>Reported value is below detection limit.

<sup>e</sup>PicoCurie(s) per gram

<sup>f</sup>Not detected

**Table 2-3a and 2-3b**  
**Shoal Mud Pit Quality Control Sample Data**

**Table 2-3a**

Sample #	Sample Date	Matrix	Arsenic ug/L <sup>a</sup>	Barium ug/L	Cadmium ug/L	Chromium ug/L	Lead ug/L	Mercury mg/L <sup>d</sup>	Selenium ug/L	Silver ug/L
PSS00003	9/11/96	Water	N/A <sup>b</sup>	1.8	N/A	2.3 (ND)	N/A	N/A	N/A	N/A
PSS00004	9/11/96	Water	0.002 (ND) <sup>c</sup>	0.083	0.0005 (ND)	0.0023 (ND)	0.0014 (ND)	0.0001 (ND)	0.0028 (ND)	0.001 (ND)
PSS00030	9/16/96	Water	N/A	0.9	N/A	4.4 (ND)	N/A	N/A	N/A	N/A
PSS00031	9/16/96	Water	20 (ND)	420	5 (ND)	23 (ND)	16	0.0001 (ND)	28 (ND)	10 (ND)

**Table 2-3b**

Sample #	Sample Date	Matrix	Diesel mg/L	Waste Oil mg/L	Tritium pCi/L <sup>e</sup>	Gross Alpha pCi/L	Gross Beta pCi/L	Cesium-137 pCi/L	Potassium-40 pCi/L
PSS00003	9/11/96	Water	0.5 (ND)	0.5 (ND)	-3.3	0.15	0.28	2.46 (ND)	ND <sup>f</sup>
PSS00004	9/11/96	Water	0.5 (ND)	0.5 (ND)	64.4	0.15	0.16	0.32 (ND)	ND
PSS00030	9/16/96	Water	0.5 (ND)	0.5 (ND)	-50	0.63	-0.43	7.71 (ND)	ND
PSS00031	9/16/96	Water	0.5 (ND)	0.5 (ND)	-112	1.81	-0.43	8.05 (ND)	ND

Note: Analytical results for volatile organic compounds for trip blank samples PST00001, PST00002, PST00003, and PST00004 were at nondetectable levels.  
Analytical results for volatile organic compounds and semi-volatile organic compounds for rinsate blanks PSS00004 and PSS00031 were at nondetectable levels.

<sup>a</sup>Microgram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Milligram(s) per liter

<sup>e</sup>PicoCuries per liter

<sup>f</sup>Not detected

### **3.0 Subsurface Investigations CAU No. 447**

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Groundwater contamination at PSA is associated with the installation and detonation of the Shoal nuclear test device. The purpose of the PSA subsurface investigation was to provide input to a groundwater model and to determine if contamination exists within groundwater proximal and/or downgradient of the Shoal test.

Subsurface investigations included the drilling and completion of four groundwater monitoring wells in the area of the Project Shoal underground nuclear test. The wells were drilled to depths approximately 396.24 m (1,300 ft) below the ground surface. Four principal locations and one alternate location were identified. Drilling pads and associated sumps were constructed at all five locations to support drilling of the wells. Due to uncertainty regarding the local groundwater gradient, the alternative site (HC-3 alt) was prepared on the western edge of the PSA in case the gradient determined from the first wells was in the western direction. [Figure 3-1](#) depicts the well site locations.

#### **3.1 Scope of Work**

The work scope for the subsurface investigation included the drilling of a 20-cm (8.0-in.) borehole using air rotary reverse circulation methods to depths sufficient to obtain approximately 91.4 m (300 ft) of saturated rock in the borehole below the static water level. As drilling advanced, hydrogeologic data were collected to determine pertinent hydrogeologic conditions. In addition to a program of regularly monitoring drill cuttings and fluid for lithologic and hydrologic characteristics, drilling effluent was collected to determine if radionuclides from the Shoal test were present. Well development followed the completion of drilling to attempt to remove drilling-related fluids from the well.

Upon completion of drilling and well development, a suite of downhole geophysical logs was run to further determine hydrogeologic conditions in the wells. The wells were then completed by installing 14-cm (5.5-in.) steel casing to a point just above the expected static water level. The casing was landed at the surface and left suspended in the well without being grouted.

#### **3.2 Drill Site and Sump Construction**

Five drill site locations were prepared to facilitate the installation of the PSA monitoring wells. Surface construction of the drill pads and sumps was conducted by Meissner Services of Lovelock, Nevada, a subcontractor under the direct supervision of the IT Corporation site

manager. Installation of liner materials in the excavated storage sumps was completed by IT Corporation personnel.

The drilling locations consisted of level earthen pads of cut and fill construction, measuring 45.7 m (150 ft) in length and 45.7 m (150 ft) in width. Two sumps were excavated within the pad area as specified in the *Fluid Management Plan (FMP) for the Project Shoal Area Offsites Subproject* (DOE/NV, 1996c). Sump No. 1 was constructed with a surface dimension of approximately 50 ft x 50 ft and 2:1 sloping walls to a depth of 6.0 ft. Sump No. 2 was constructed with a surface dimension of 40 ft x 40 ft and 2:1 sloping walls to a depth of 6 ft.

As specified in the FMP (DOE/NV, 1996c), sump liners were installed in each of the excavated sumps. The sumps were constructed and lined in two configurations. A single 36-mil (.036-in.) Hypalon liner was installed in one of the sumps to provide for storage of uncontaminated fluids and cuttings, and two 36-mil (.036-in.) liners separated by 200-mil (.200-in.) geonet were installed with a leak detection system in the second sump. Liners were all installed on 0.34 kilogram (12-ounce) Geotextile material to prevent puncture from earthen materials within the excavated sump.

### **3.3 Summary of Monitoring Well Drilling and Completion Operations**

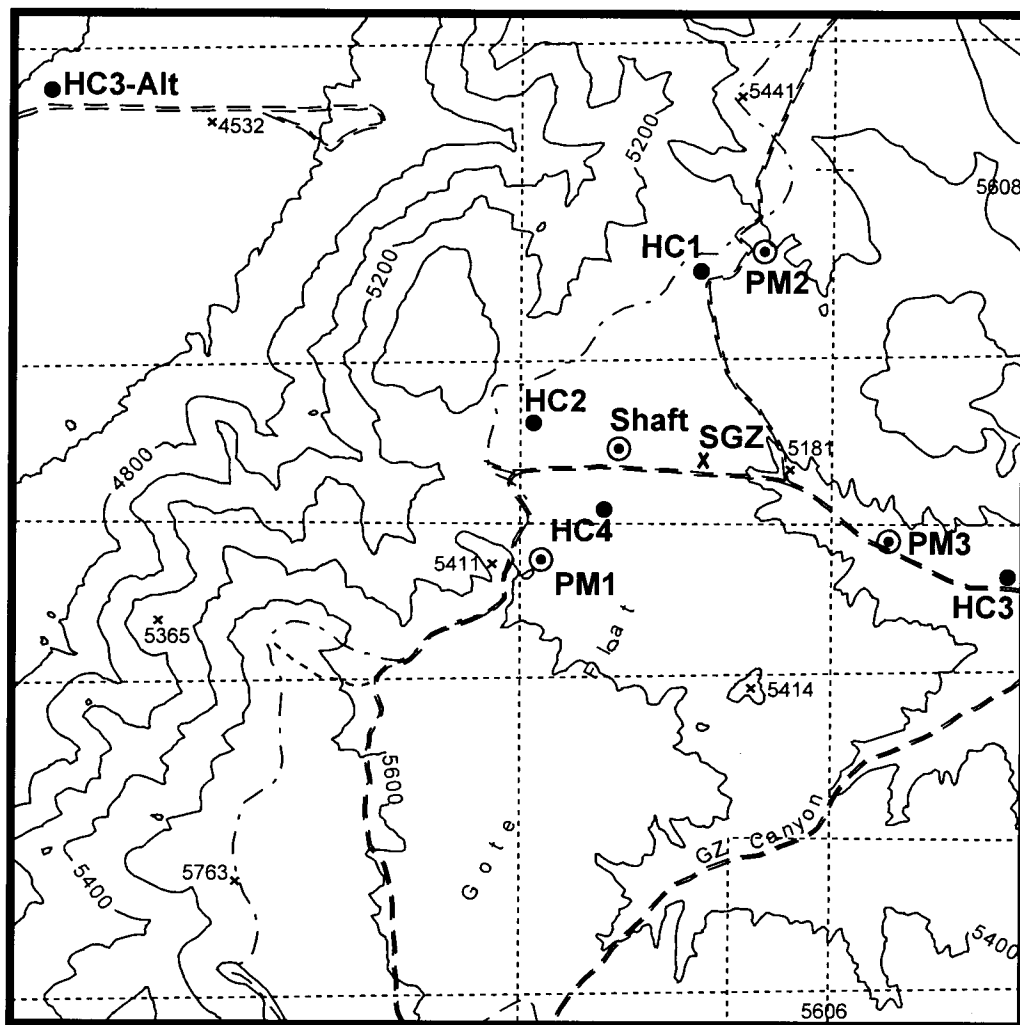
Drilling of monitoring wells at the PSA commenced on September 9, 1996, and was completed on November 13, 1996. Forty-one days were spent drilling and completing the wells. Operations were conducted 7 days per week, 24 hours per day for the term of the project. Several short breaks (2 to 3 days) were taken due to unplanned equipment breakdowns and to give the staff a break.

The four monitoring wells were drilled in the following order: HC-1, HC-2, HC-4, and HC-3. All wells were drilled to approximately 396.2 m (1,300 ft) bgs. The total drilled footage for the project was 1,600.8 m (5,252 ft). Well Site HC-3 was used instead of Alternative 3 because the results obtained from the installation of Wells HC-1, HC-2, and HC-4 indicated that the potentiometric surface dipped to the east. All drilling was conducted using air rotary reverse circulation methods. Wells were completed by installing threaded and coupled 14-cm (5.5-in.) carbon steel casing to a point just above the static water table. The casing was not cemented in place to facilitate later removal or repositioning based on modification of scientific objectives or changes in static water levels within the wells. Well HC-1 was originally drilled and completed to a depth of 323.1 m (1,060 ft); however, it was later reentered, drilled, and completed to a depth of 409.35 m (1,343 ft) because of falling water levels within the well.

The groundwater flow gradient was interpreted based on water levels obtained from the four wells installed in the subsurface investigation. The flow gradient is apparently in an east-southeast direction as depicted in [Figures 3-2 and 3-3](#).

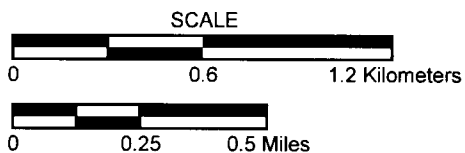
Regular monitoring of drilling effluent for tritium and other radionuclides was conducted on all of the wells during drilling and development. No indications of radiation above background levels were noted.

Drilling and well completions were conducted by Beylik Drilling of North Highlands, California. Borehole geophysical logging was conducted by Century Geophysical Corporation of Tulsa, Oklahoma, and borehole video logs and additional geophysical logging were conducted by the Desert Research Institute (DRI). Beylik Drilling and Century Geophysical Corporation were both direct subcontractors to IT. Well drilling, construction, and geophysical logging operations were directly supervised by IT.



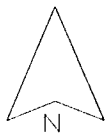
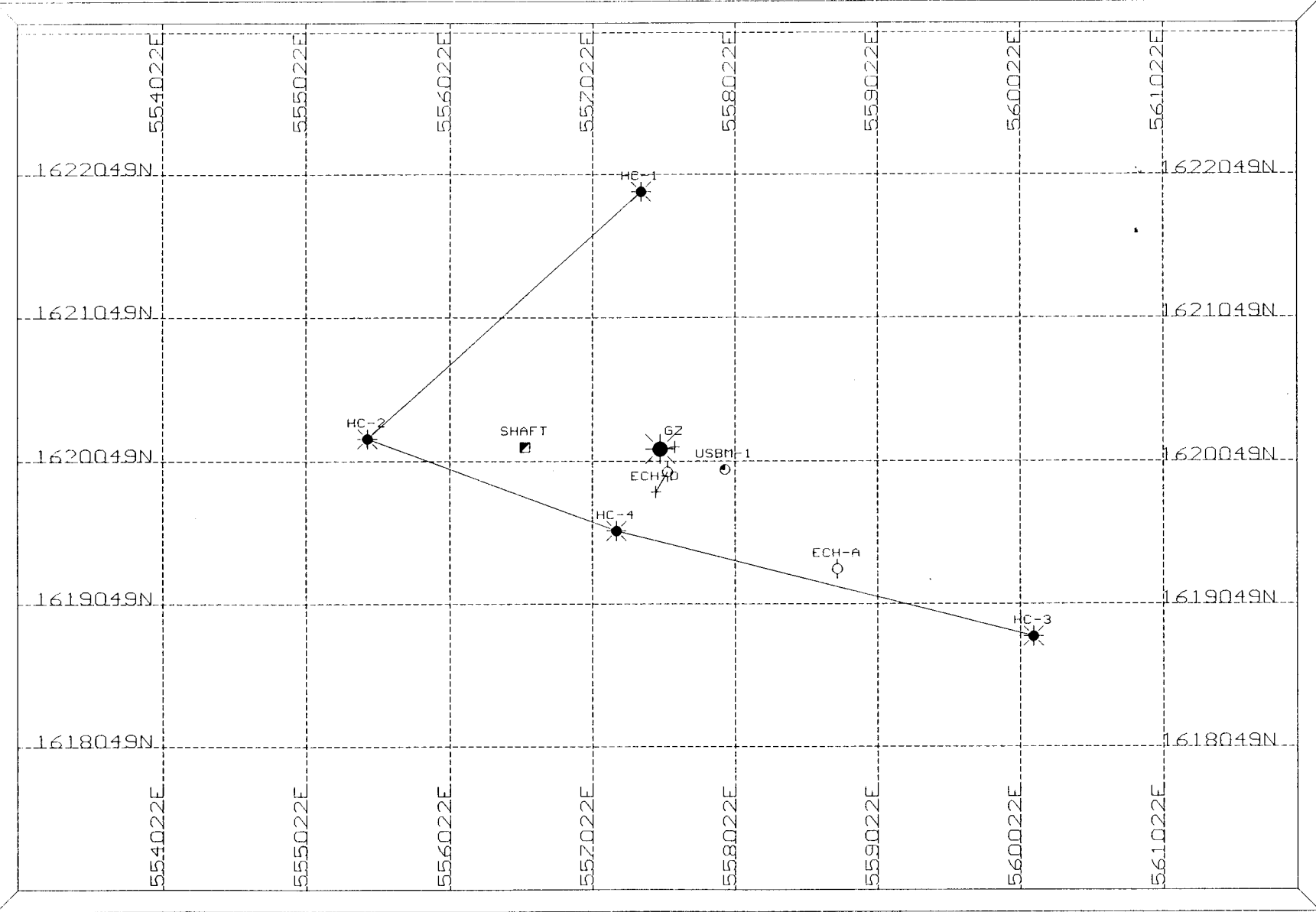
**LEGEND**

- ⊙ Abandoned well or boring
- Proposed well (approximate location)
- Withdrawn area boundary
- Topographic contour (Interval = 200 feet)
- ×5365 Point elevation
- - - Unpaved road
- SGZ** Surface ground zero
- - - Approximate location of groundwater divide



Source: DOE, 1996

**Figure 3-1**  
**Shoal Well Location Map**



# SHOAL PROJECT WELLS

X-SEC LOCATION MAP

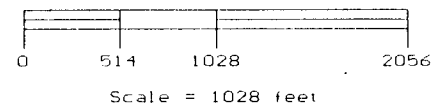
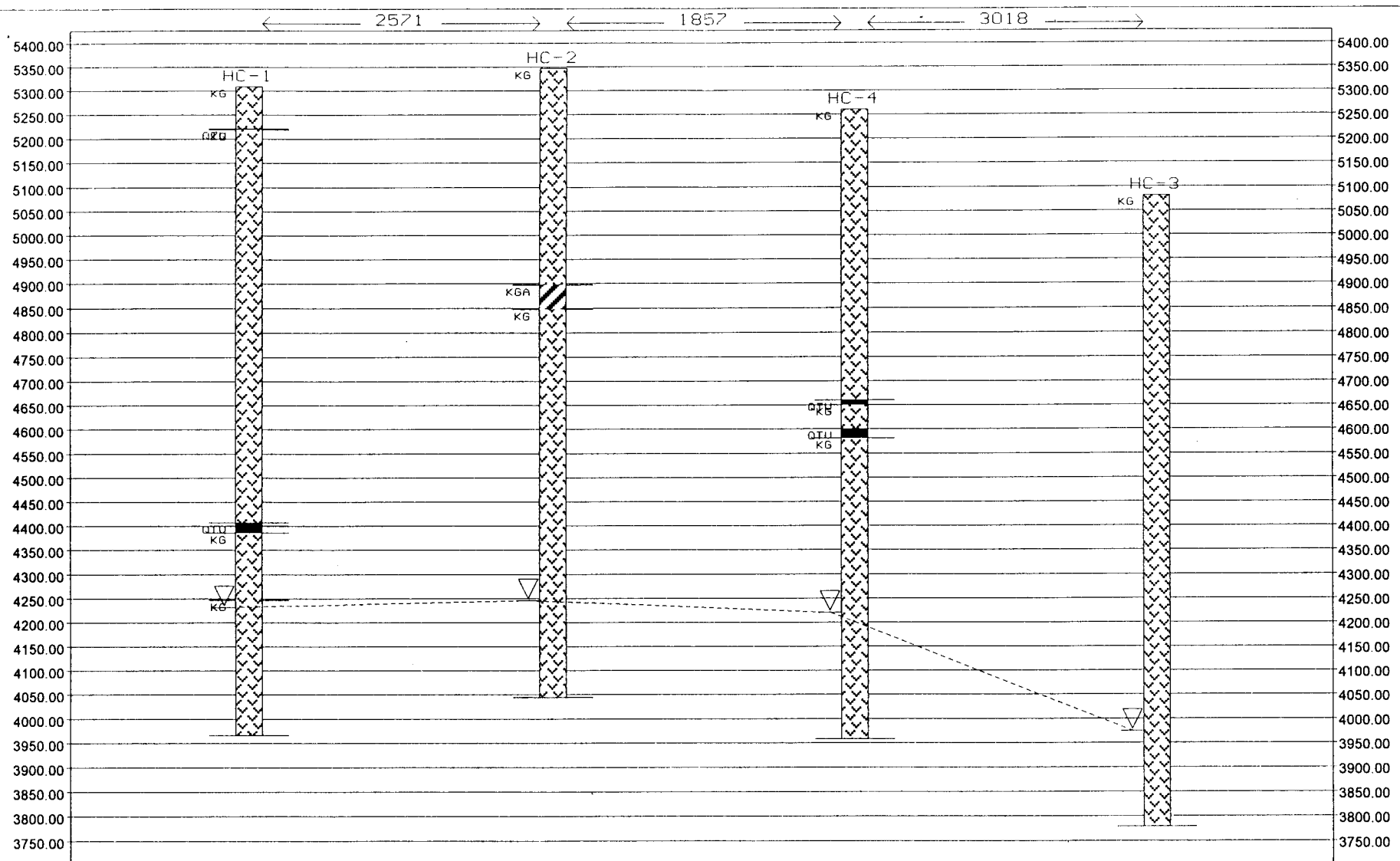


Figure 3-2  
Shoal Project Well Cross Section Location

Figure 3-3  
Shoal Flow Gradient Cross Section  
3-6



0.0  
152.5  
305.0  
Scale = 305.0

SHOAL PROJECT WELLS

FLOW GRADIENT X-SEC

## **4.0 Well HC-1 Summary of Operations**

---

Well HC-1 was initially drilled to a depth of 323.09 m (1,060.0 feet) between September 26, 1996, and October 2, 1996, and then reentered on October 25, 1996, and advanced to a depth of 409.35 m (1,343.0 ft). The final completion of the well occurred on October 28, 1996. A total of 13 days, including both phases, was spent drilling and completing this well. [Figure 4-1](#) is a summary of the drilling parameters for the well. Note that [Figures 4-1 through 4-10](#) and [Tables 4-1 through 4-5](#), cited in the following text, are located at the end of this section.

Prior to mobilization, all drilling equipment was decontaminated at the on-site decontamination pad using a combination of steam cleaning and high pressure washing. Decontaminated equipment was subjected to a final radiologic screening prior to movement to the drill site.

Initial drilling of Well HC-1 commenced on September 26, 1996. A 30.48-cm (12.0-in.) hole was drilled to a depth of 31.00 m (101.7 ft). A 21.90-cm (8.625-in.) conductor casing was installed in the borehole and cemented in place. The main hole of the well was advanced using an 20.3-cm (8.0-in.) downhole percussion hammer and air rotary reverse circulation drilling techniques to an initial total depth (TD) of 323.09 m (1,060.0 ft).

The initial depth of Well HC-1 was determined from where water was first encountered during drilling and then compared to historic water levels from nearby wells. Given this information, it was decided the well would provide adequate open borehole below the estimated water level for later scientific investigations to be conducted by DRI.

Due to unstable, sloughing borehole conditions, the well could not be developed/cleaned using reverse circulation drilling techniques. The drilling configuration was then changed to conventional direct circulation, and the well was developed. Foam drilling additives were used initially to establish circulation. The well was then completed by installing 13.97-cm (5.5-in.) carbon steel casing to a depth of 291.51 m (956.4 ft) and landing the casing in suspension from a landing plate mounted on the surface casing.

Water-level monitoring, conducted by DRI and IT after completion of the well, indicated that water levels within the well were consistently falling with time. These water levels indicated that the well was not drilled to a depth suitable for scientific study of the saturated portions of the well.

After approval by the DOE, the 13.97-cm (5.5-in.) intermediate casing was pulled from HC-1, and the well was reentered with a 20.00-cm (7.875-in.) percussion hammer. The bottom of the hole was drilled using air rotary reverse circulation drilling techniques and advanced to a depth of 409.35 m (1,343.0 ft). The hole began to slough in at this point, and additional time was spent working to extract the drill pipe from the hole. After pulling the 20.00-cm (7.875-in.) drilling assembly from the hole, a depth check was made to determine the TD of the well. It was determined that the well had sloughed in to a depth of 406.91 m (1,335.0 ft).

Intermediate casing (13.97 cm [5.5 in.]) was then re-installed in the well to 333.70 m (1,094.8 ft) bgs. After landing the casing, the hole was reentered with a 11.75-cm (4.625-in.) tricone button bit, again using reverse circulation in an effort to clean the hole out to the total drilled depth of the well (409.35 m [1,343.0 ft]). The well was circulated and cleaned to the bottom, and the final depth of the well was 403.80 m (1,324.8 ft). The drilling assembly was then pulled from the borehole, and the drilling equipment was rigged down for decontamination and mobilization to HC-2.

#### **4.1 Well HC-1 Geology**

Well HC-1 encountered a fractured, coarse-grained biotite granite throughout the drilled interval. Several, thin, 3- to 6-m (10- to 20-ft) intrusive dikes of Tertiary-aged andesite were noted between 274.93 and 281.33 m (902.0 and 923.0 ft). The andesite dikes were localized along steep fault and fracture zones within the granite. These andesite filled fracture/fault zones were primarily responsible for borehole sloughing and unstable drilling conditions. Descriptions of the lithologies that were encountered are provided as [Figure 4-2](#).

#### **4.2 Well HC-1 Hydrology**

Several elements of hydrologic importance were monitored during and after completion of the well. During drilling, two parameters were consistently compared: the volume of drilling fluid (water) injected to facilitate drilling and the volume of fluid produced as discharge to the surface. [Figure 4-3](#) illustrates the relationship between injected drilling fluids and drilling fluid produced at the surface.

In addition to volumetric measurements, all drilling fluids injected into the borehole were tagged with a tracer solution of Lithium Bromide (LiBr). The concentration of LiBr in solution was monitored on a regular basis to estimate groundwater production within the borehole. [Table 4-1](#) illustrates LiBr concentrations noted in produced fluids.

Water production from the well was minimal; monitoring data and water level recovery data suggests the well was capable of producing approximately 2.8 to 3.8 liters per minute (L/min) (0.75 to 1.0 gallons per minute [gpm]). During several instances, the well was capable of intermittent production on the order of 11.4-18.9 L/min (3.0 to 5.0 gpm). These readings suggest production from perched water zones along fault or fracture zones. These zones were of limited impact as their storage capacity was exhausted, and in turn, their contribution to the well decreased.

Water-level monitoring was conducted during the construction of the well and continued after completion using transducers set by DRI. [Table 4-2](#) provides water levels obtained for the term of IT involvement in PSA field work.

### **4.3 Well HC-1 Geophysical Surveys**

Upon completion of drilling to the initial TD of 323.09 m (1,060.0 ft) and after well development, a suite of downhole geophysical surveys was run within the borehole. Upon reentering the well and deepening the borehole, a second phase of geophysical logging occurred to capture geophysical data from the deepened interval 323.09 to 409.35 m (1,060.0 to 1,343.0 ft). Due to the instability of the borehole, it was necessary to install casing across an interval not logged in the first logging session; in turn, certain intervals of the borehole were not available for logging.

Deviation surveys were also conducted within the borehole and indicated the borehole was deviated 14.2 degrees from vertical in a west-southwest direction. The deviation of the hole placed the bottom of the hole 79.68 m (261.4 ft) west-southwest of the collar and resulted in a true vertical depth of 394.68 m (1,294.87 ft) bgs.

[Table 4-3](#) provides a summary of the geophysical logs run for the well. [Figures 4-4 to 4-7](#) provide a condensed illustration of log traces for HC-1.

#### **4.4 Well HC-1 Radiologic Monitoring**

Monitoring of discharge effluent from drilling was conducted as specified in the *Project Shoal Site-Specific Health and Safety Plan* (SSHASP) (DOE/NV, 1996b) and the FMP for the Project Shoal Area Offsite Subproject (DOE/NV, 1996c). Regular radiological monitoring of discharged drilling effluents, including both fluids and solids, was conducted by Bechtel Nevada radiation control technicians.

Samples were screened using hand-held instruments at the time of collection. Effluents were further analyzed for tritium and other radionuclides using on-site laboratory monitoring equipment. Tritium activities from fluid and swiped samples were recorded using a Packard Liquid Scintillation instrument. Other radionuclides were analyzed using Canberra gamma spectroscopy instrumentation.

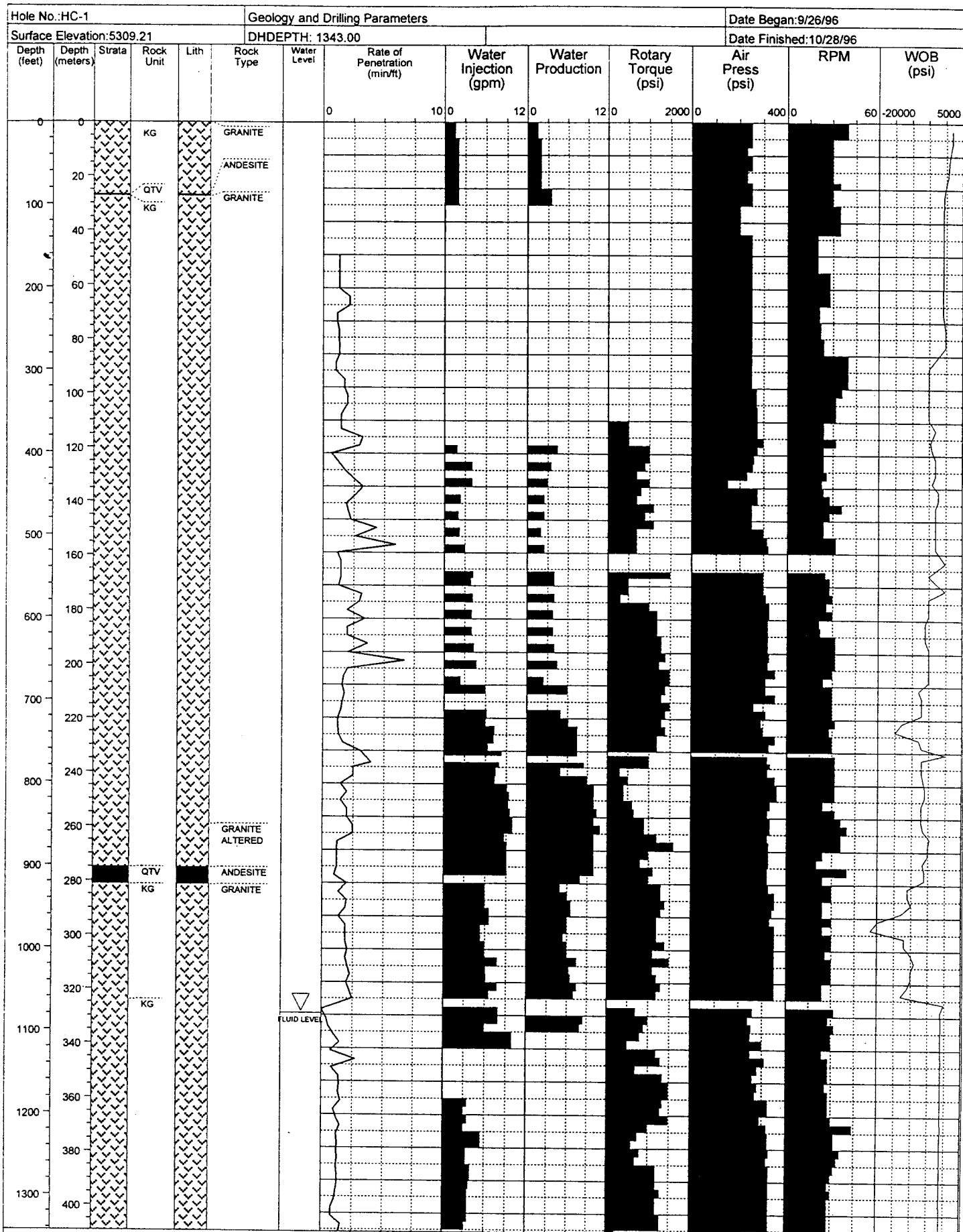
Based on field monitoring, Well HC-1 effluents were found to contain natural background levels of tritium and all other radionuclides. [Figure 4-8](#) provides a profile of tritium encountered in the well.

#### **4.5 Well HC-1 Well Construction**

Well HC-1 drilling operations commenced on September 26, 1996. A 30.48-cm (12.0-in.) surface hole was drilled to a depth of 31.00 m (101.7 ft) bgs using a downhole percussion hammer and air rotary reverse circulation drilling techniques. The 21.91-cm (8.625-in.) surface conductor casing was then set and cemented in place using Type II neat cement with an additive of 2 percent calcium chloride. An 20.32-cm (8.0-in.) hole was advanced below the surface conductor casing using 20.32 cm (8.0-in.) downhole percussion hammer and reverse circulation to a final depth of 409.34 m (1,343.0 ft) bgs. Intermediate casing consisting of 13.97-cm (5.5-in.) carbon steel was installed in the well upon completion of main hole drilling. Casing was set to a depth of 333.45 m (1,094.0 ft) and suspended at that point from a landing clamp secured to the surface conductor casing. No centralizers or cementing baskets were placed on the 13.97-cm (5.5-in.) casing string due to unstable borehole conditions. [Figure 4-9](#) illustrates the final subsurface well completion, and the surface completion of HC-1 is presented on [Figure 4-10](#).

#### **4.6 Well HC-1 Sampling**

Samples for analytical analysis were collected from fluids and cuttings as specified in the *Field Instructions for Project Shoal Area Surface and Subsurface Investigation, Churchill County, Nevada* (IT, 1996) and the FMP for the Project Shoal Area Offsites Subproject (DOE/NV, 1996c). The sample type and analytical results from these samples are shown in [Tables 4-4 and 4-5](#).



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 4-1**  
**Summary of Well HC-1 Drilling Parameters**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

Shoal Project  
Churchill Co Nevada  
Project No. 764044.03.07.00.00  
IT Corporation Offsites Project  
Lithologic Descriptions by Well

Well ID. HC-1 GRANITE 0.00 88.00 jaw 09/29/96  
Granite, mottled grayish white to white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm 20%, minor plagioclase <10%

Well ID. HC-1 ANDESITE 88.00 90.00 jaw 09/29/96  
Andesite, light grayish green to greenish gray, weakly porphyritic with thin laths <1.5 mm plagioclase (10%), minor hornblende as thin tabular xls in a fine grained groundmass. Potential fracture zone. Large rubbly cuttings 10-15mm

Well ID. HC-1 GRANITE 90.00 300.00 jaw 09/29/96  
Granite, mottled grayish white to white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Possible fracture or fractures within the interval 230-240. Pale yellow to ochreous orange stains along micro fractures and xl boundaries. Good quality cuttings 2-3mm

Well ID. HC-1 GRANITE 300.00 400.00 jaw 10/02/96  
Granite, mottled grayish white to white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses or clots to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky gray quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Possible fracture or fractures within the interval 320-330 and 360-370. Pale yellow to ochreous orange stains along micro fractures and xl boundaries. Good quality cuttings 2-3mm

Well ID. HC-1 GRANITE 400.00 460.00 jaw 10/02/96  
Granite, mottled grayish white to white, porphyritic, with abundant black to greenish black biotite xl altering locally to chlorite principally as 2-5mm irregular aggregate masses or clots to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky gray quartz, (30%), milky white anhedral subhedral kspar as microcline (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Fault/fracture or fracture zone within the interval 400-450. Some cutting show slickensides and fracture cleavage Pale yellow to ochreous orange stains along micro fractures and as halos surrounding clots and xl of chlorite boundaries. Large rubbly cuttings ranging 10-20mm.

Well ID. HC-1 GRANITE 460.00 510.00 jaw 10/02/96  
Granite, mottled grayish white to white, porphyritic, with abundant black to greenish black biotite xl altering locally to chlorite principally as 2-5mm irregular aggregate masses or clots to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky gray quartz, (30%), milky white anhedral subhedral kspar as microcline (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Fault/fracture or fracture zone within the interval 400-450. Some cutting show slickensides and fracture cleavage. Pale yellow to ochreous orange stains along micro fractures and as halos surrounding clots and xl of chlorite boundaries. Good quality cuttings 3-5mm.

Well ID. HC-1 GRANITE 510.00 850.00 jaw 10/02/96  
Granite, mottled grayish white to white, porphyritic, with abundant black to greenish black biotite xl altering locally to chlorite principally as 2-5mm irregular aggregate masses or clots to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky gray quartz, (30%), milky white anhedral subhedral kspar as microcline (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Very faint less prominent pale yellow to ochreous orange stains along micro fractures and as halos surrounding clots and xl of chlorite boundaries. Good quality cuttings 3-5mm. Fracture zone 640-660 ?? large cuttings noted.

Figure 4-2  
Well HC-1 Lithologic Descriptions  
(Page 1 of 2)

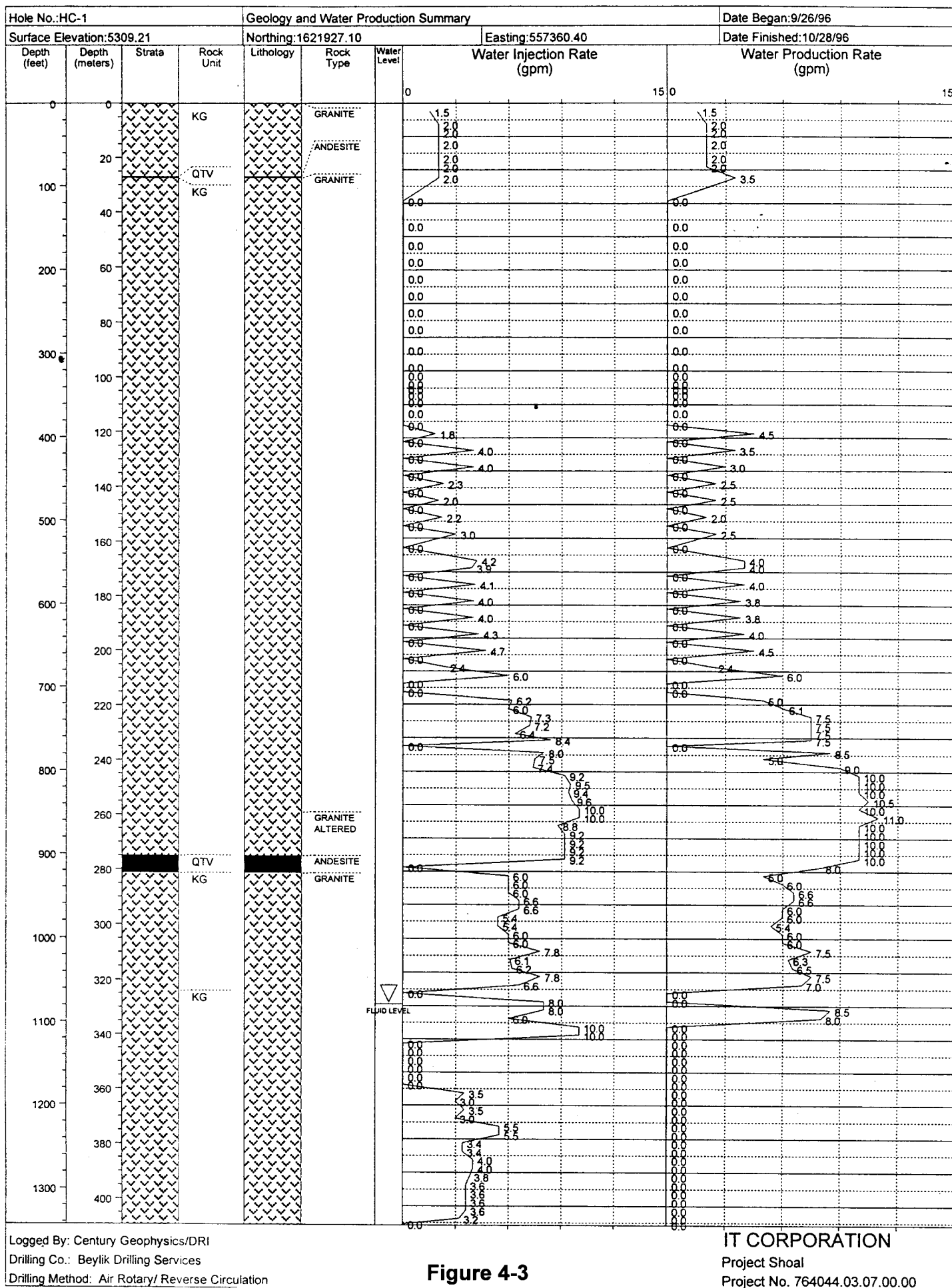
Well ID. HC-1                      GRANITE                      850.00    902.00    jaw 10/02/96  
Granite, mottled grayish white to white to light blue gray, interval is bleached and strongly chloritized, some local silicification, porphyritic with abundant chlorite after biotite, pervasive bluish green stained quartz and microcline. Fracture and micro fractures coated with stains and thin coatings of limonite. Rock is similar in composition to granite above yet altered.

Well ID. HC-1                      ANDESITE                      902.00    923.00    jaw 10/02/96  
Andesite, dark grayish blue to dark gray, very fine grain to aphanitic, some unidentified dark phenocrysts (< 1%) apparent. Cuttings(5-15mm) are generally platy and have weak fracture/flow cleavage. Some strongly altered granitic cuttings 10-20 mm with strong hematite/limonite staining. Fault/fracture zone filled by an andesite dike.

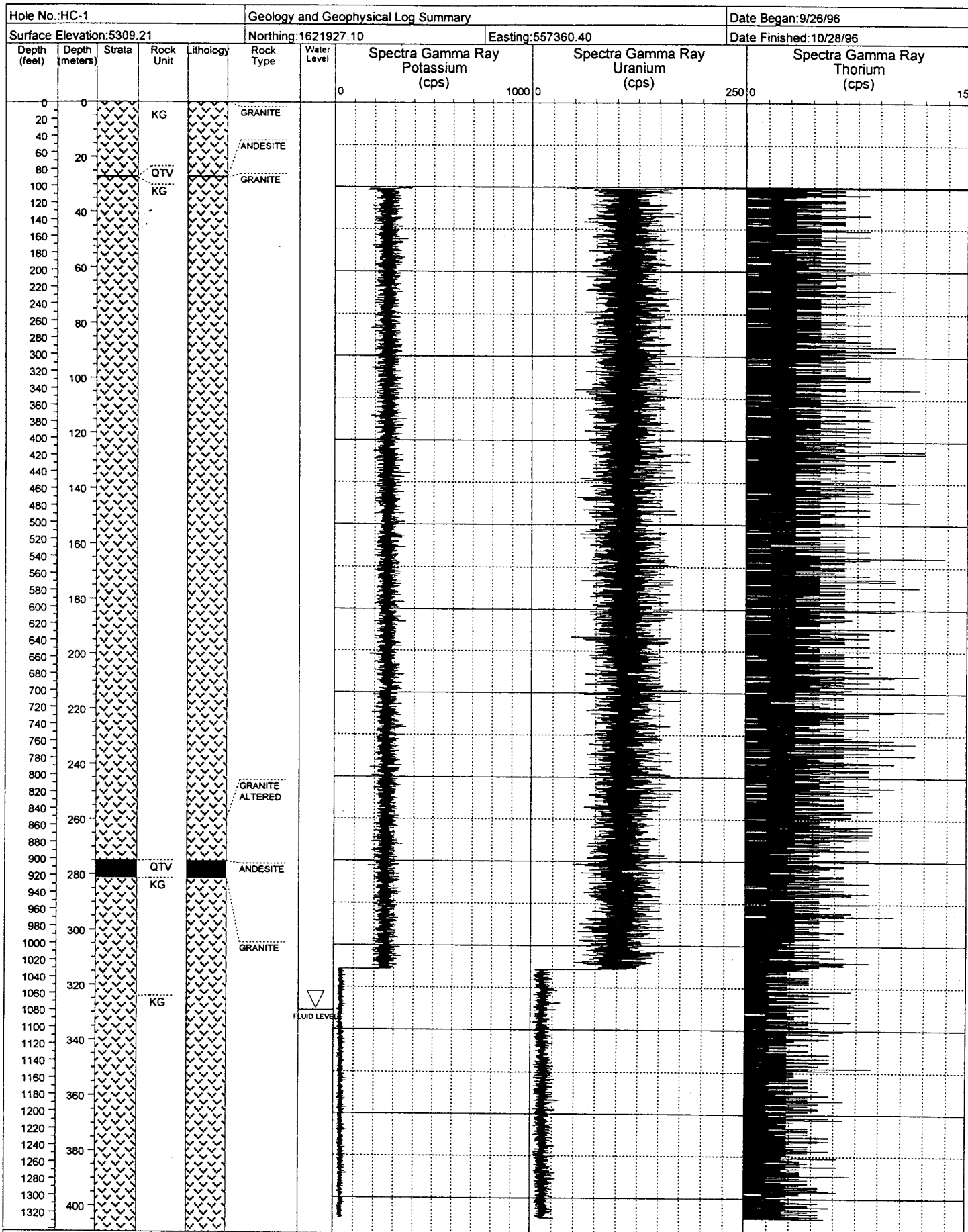
Well ID. HC-1                      GRANITE                      923.00    1063.00    jaw 10/02/96  
Granite, mottled grayish white to white, porphyritic, with abundant black to greenish black biotite xl altering locally to chlorite principally as 2-5mm irregular aggregate masses or clots to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky gray quartz, (30%), milky white anhedral ksp as microcline (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Very faint less prominent pale yellow to ochreous orange stains along micro fractures and as halos surrounding clots and xl of chlorite boundaries. Poor quality cuttings 3-5mm with much cross contamination with cuttings of uphole lithologies most predominated by andesite.

Well ID. HC-1                      GRANITE                      1063.00    1343.00    jaw 10/27/96  
Mixed lithologies of granite and andesite as described above. much cross contamination from sloughing zones encountered above.

**Figure 4-2**  
**Well HC-1 Lithologic Descriptions**  
(Page 2 of 2)



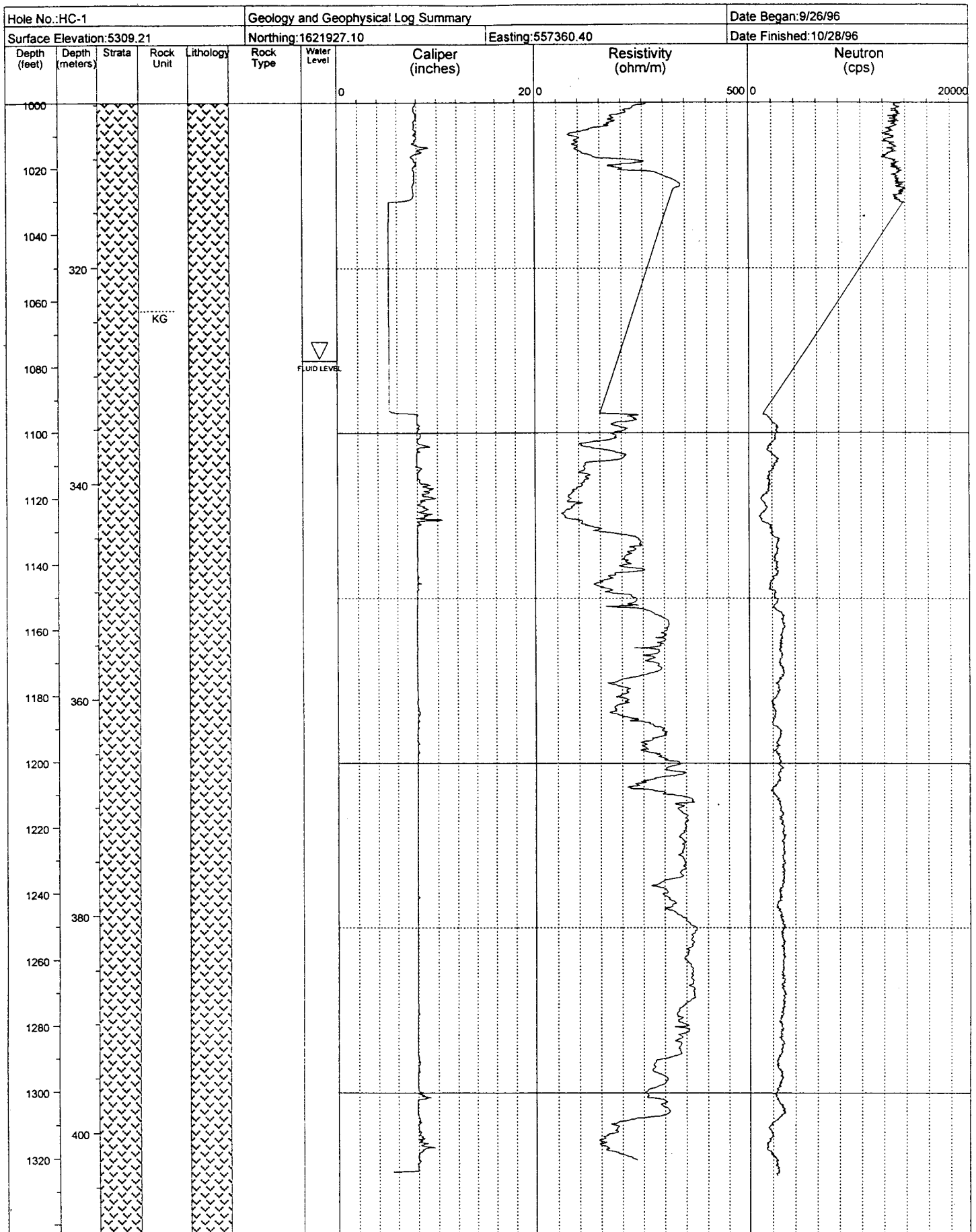
**Figure 4-3**  
**HC-1 Fluid Injection versus Production Diagram**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

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 Project Shoal  
 Project No. 764044.03.07.00.00

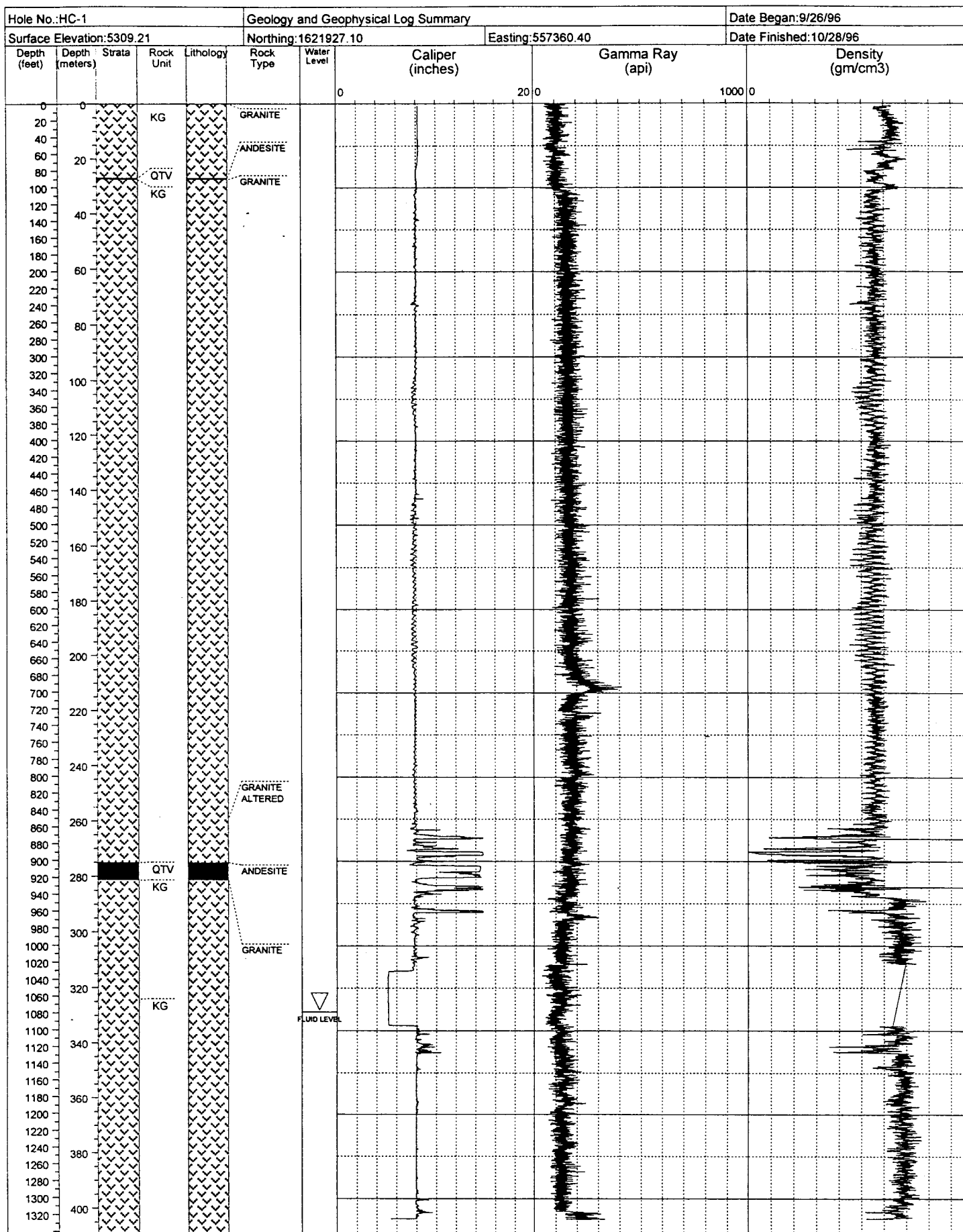
**Figure 4-4**  
**HC-1 Geophysical Log Traces of Spectra Gamma Ray**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

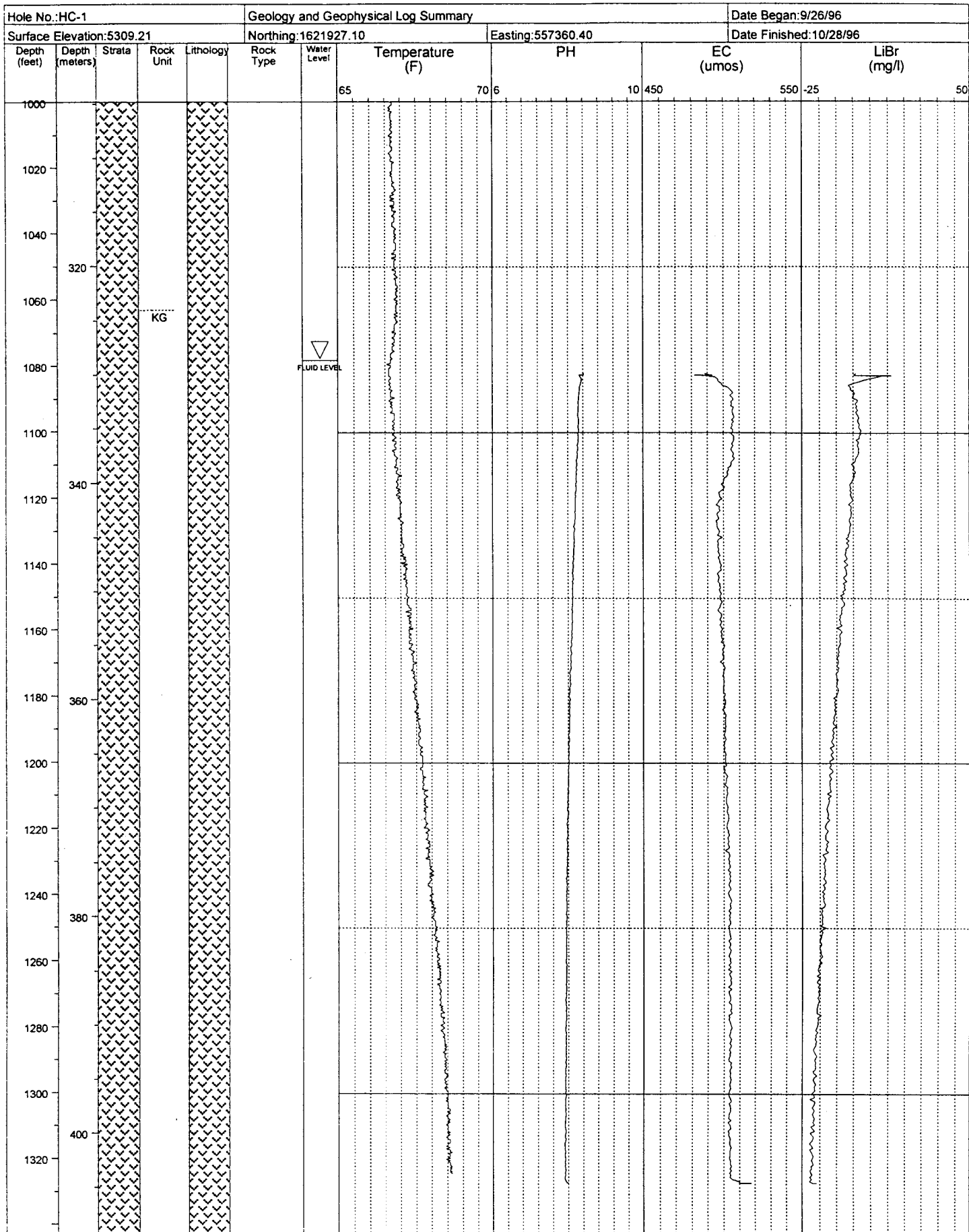
**Figure 4-5**  
**HC-1 Geophysical Log Traces of Caliper, Resistivity, Neutron**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

**Figure 4-6**  
**HC-1 Geophysical Log Traces of Caliper, Gamma Ray, Density**



Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

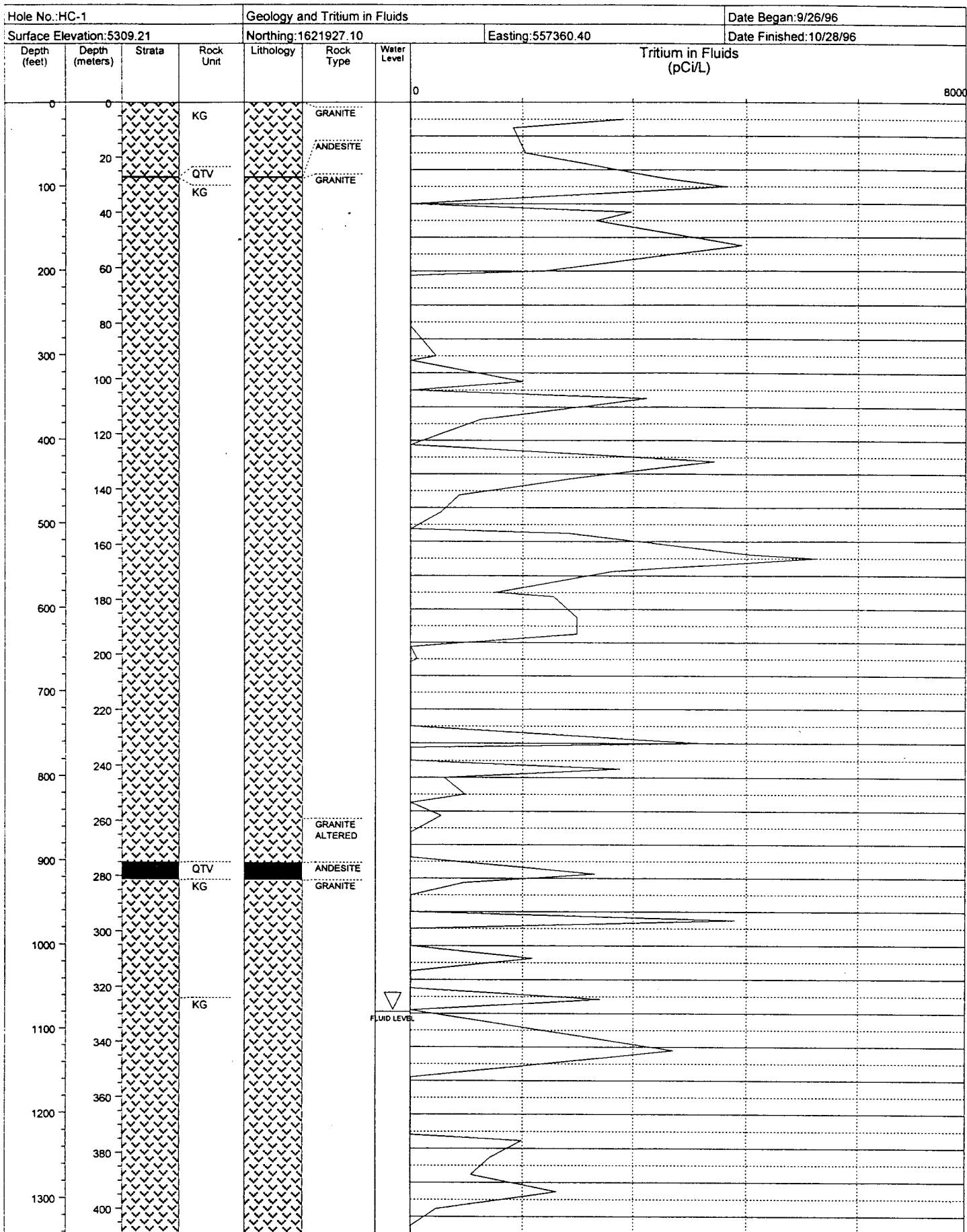
Figure 4-7

HC-1 Geophysical Log Traces of Chemtool

IT CORPORATION

Project Shoal

Project No. 764044.03.07.00.00



Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

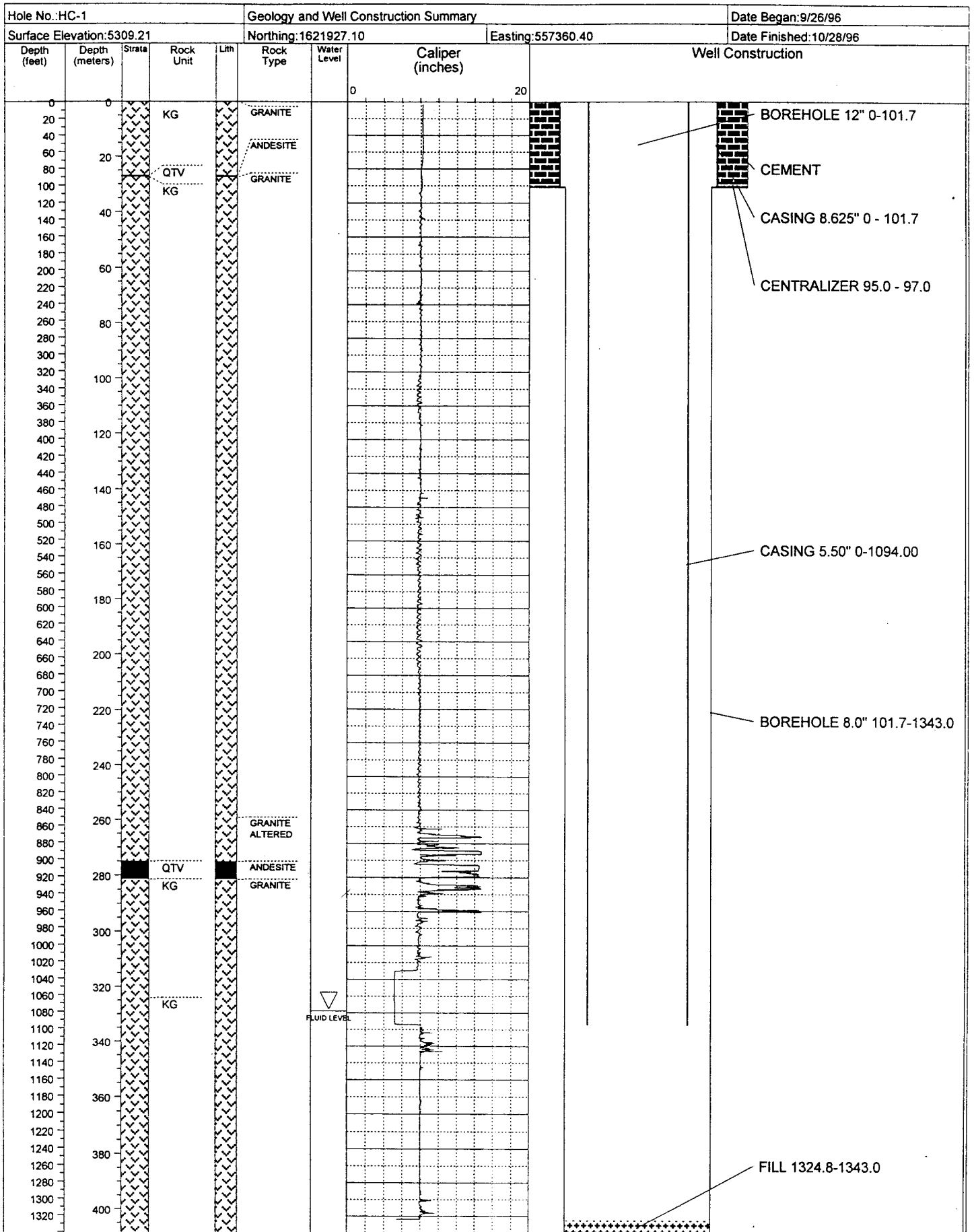
**Figure 4-8**

**HC-1 Tritium Concentrations During Drilling**

**IT CORPORATION**

Project Shoal

Project No. 764044.03.07.00.00



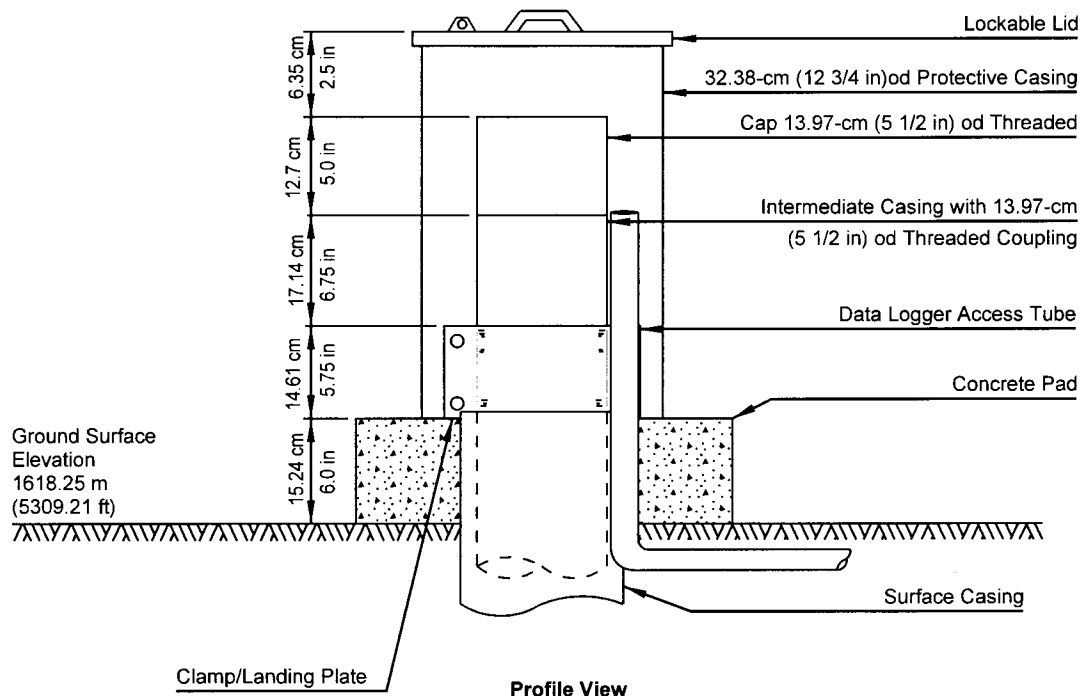
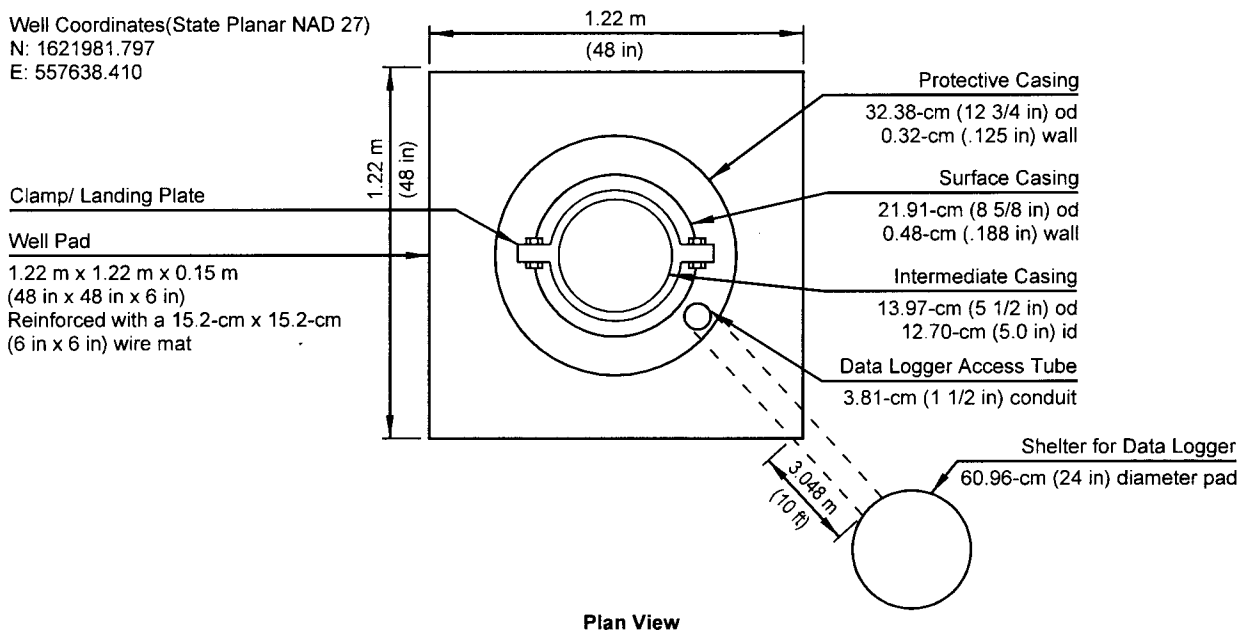
Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 4-9**  
**HC-1 Subsurface Well Completion Diagram**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00



Well Coordinates(State Planar NAD 27)  
 N: 1621981.797  
 E: 557638.410



**Figure 4-10**  
**HC-1 Well Head Completion Diagram**

**Table 4-1**  
**Well HC-1 Lithium Bromide Concentrations**  
 (Page 1 of 3)

Date mm/dd/yy	Time (24 hrs)	Depth (ft)	Sample Conc. (mg/L)	Sample Temp (C°)	Sample Source	Analysis By
9/29/96	2145	N/A <sup>a</sup>	20.5	20.3	QCCS Standard	A.M. Welcher
9/29/96	2245	N/A	60.1	20.4	Water Truck	A.M. Welcher
9/29/96	2315	420	59.8	20.8	Discharge Line	A.M. Welcher
9/29/96	2345	425	60.5	21.2	Discharge Line	A.M. Welcher
9/29/96	0	N/A	19.9	19.7	QCCS Standard	A.M. Welcher
9/30/96	30	N/A	54.3	20.6	Water Truck	A.M. Welcher
9/30/96	100	N/A	20.5	19.5	QCCS Standard	A.M. Welcher
9/30/96	45	445	60.5	21.1	Discharge Line	A.M. Welcher
9/30/96	325	N/A	54.5	21.6	Water Truck	A.M. Welcher
9/30/96	325	465	59.8	21.6	Discharge Line	A.M. Welcher
9/30/96	425	N/A	57.5	21.1	Water Truck	A.M. Welcher
9/30/96	425	485	47.0	21.1	Discharge Line	A.M. Welcher
9/30/96	435	N/A	19.4	21.1	QCCS Standard	A.M. Welcher
9/30/96	525	505	58.4	21.7	Discharge Line	A.M. Welcher
9/30/96	615	510	56.6	22.0	Discharge Line	J. Saavedra
9/30/96	2220	N/A	20.6	21.9	QCCS Standard	A.M. Welcher
9/30/96	1945	555	82.4	20.9	Discharge Line	A.M. Welcher
9/30/96	2005	N/A	61.1	21.5	Water Truck	M. Flaughner
9/30/96	2040	N/A	59.3	22.3	Water Truck	M. Flaughner
9/30/96	2045	580	80.2	21.8	Discharge Line	M. Flaughner
9/30/96	2150	N/A	59.3	22.3	Water Truck	M. Flaughner
9/30/96	2241	N/A	25.7	21.4	QCCS Standard	M. Flaughner
9/30/96	2145	585	66.2	22.1	Discharge Line	M. Flaughner
9/30/96	2245	N/A	60.6	23.0	Water Truck	M. Flaughner
9/30/96	2245	610	79.9	21.4	Discharge Line	A.M. Welcher
9/30/96	2345	N/A	8.8	23.0	Portable Water Tank	A.M. Welcher
9/30/96	2345	630	6.8	22.3	Discharge Line	A.M. Welcher
9/30/96	2355	N/A	21.2	20.9	QCCS Standard	A.M. Welcher
10/1/96	45	N/A	36.9	21.1	Water Truck	A.M. Welcher
10/1/96	45	645	45.1	21.1	Discharge Line	A.M. Welcher
10/1/96	145	N/A	34.9	20.9	Water Truck	A.M. Welcher
10/1/96	145	660	48.1	21.0	Discharge Line	A.M. Welcher
10/1/96	530	N/A	22.7	20.5	QCCS Standard	A.M. Welcher
10/1/96	1203	N/A	20.5	20.8	QCCS Standard	J. Wurtz
10/1/96	1345	663	60.9	20.3	Discharge Line	J. Saavedra
10/1/96	1430	680	49.0	21.0	Discharge Line	J. Saavedra
10/1/96	1430	N/A	45.1	20.8	Water Truck	J. Saavedra
10/1/96	1515	700	48.5	20.4	Discharge Line	J. Saavedra
10/1/96	1515	N/A	49.6	20.2	Water Truck	J. Saavedra
10/1/96	1800	N/A	25.7	19.9	QCCS Standard	J. Saavedra
10/1/96	1615	N/A	53.2	20.0	Water Truck	J. Saavedra
10/1/96	1615	720	56.7	19.8	Discharge Line	J. Saavedra
10/1/96	1650	N/A	44.3	20.0	Water Truck	J. Saavedra
10/1/96	1650	723	47.5	20.2	Discharge Line	J. Saavedra
10/1/96	1735	N/A	53.7	20.2	Water Truck	J. Saavedra
10/1/96	1822	N/A	25.7	20.1	QCCS Standard	J. Saavedra
10/1/96	1735	740	30.3	21.2	Discharge Line	J. Saavedra
10/1/96	1830	N/A	37.2	19.9	Water Truck	J. Saavedra
10/1/96	1830	760	37.1	21.2	Discharge Line	J. Saavedra
10/1/96	1905	760	65.0	21.0	Discharge Line	R. Peterson
10/1/96	1925	N/A	21.6	21.1	QCCS Standard	R. Peterson
10/1/96	1920	760	69.5	20.6	Discharge Line	R. Peterson
10/1/96	2043	N/A	28.5	20.5	Water Truck	R. Peterson
10/1/96	2041	780	27.3	20.9	Discharge Line	R. Peterson

**Table 4-1**  
**Well HC-1 Lithium Bromide Concentrations**  
(Page 2 of 3)

Date mm/dd/yy	Time (24 hrs)	Depth (ft)	Sample Conc. (mg/L)	Sample Temp (C°)	Sample Source	Analysis By
10/1/96	2049	780	28.7	20.7	Discharge Line	R. Peterson
10/1/96	2130	780	31.3	21.2	Discharge Line	R. Peterson
10/1/96	2145	N/A	20.9	20.0	QCCS Standard	R. Peterson
10/1/96	2150	780	33.2	20.4	Discharge Line	A.M. Welcher
10/1/96	2345	N/A	19.3	20.4	QCCS Standard	A.M. Welcher
10/2/96	105	790	34.1	21.2	Discharge Line	R. Peterson
10/2/96	150	803	31.9	20.1	Water Truck	R. Peterson
10/2/96	135	800	37.0	21.4	Discharge Line	R. Peterson
10/2/96	245	N/A	23.3	20.6	QCCS Standard	R. Peterson
10/2/96	220	820	36.0	21.7	Discharge Line	R. Peterson
10/2/96	320	830	37.3	21.5	Discharge Line	A.M. Welcher
10/2/96	420	845	32.6	21.2	Discharge Line	A.M. Welcher
10/2/96	455	N/A	41.5	20.1	Water Truck	A.M. Welcher
10/2/96	510	N/A	24.0	20.3	QCCS Standard	A.M. Welcher
10/2/96	530	N/A	23.7	20.4	QCCS Standard	A.M. Welcher
10/2/96	520	N/A	38.2	20.6	Water Truck	A.M. Welcher
10/2/96	520	865	32.6	22.1	Discharge Line	A.M. Welcher
10/2/96	544	880	43.3	19.6	Water Truck	R. Peterson
10/2/96	610	895	36.9	21.2	Discharge Line	R. Peterson
10/2/96	610	N/A	34.9	21.3	Water Truck	R. Peterson
10/2/96	640	920	30.9	22.5	Discharge Line	R. Peterson
10/2/96	735	N/A	25.4	20.9	QCCS Standard	R. Peterson
10/2/96	800	940	40.4	19.2	Discharge Line	J Saavedra
10/2/96	800	N/A	40.2	19.1	Water Truck	J Saavedra
10/2/96	910	N/A	8.4	18.9	PT	J Saavedra
10/2/96	910	960	44.5	18.9	Discharge Line	J Saavedra
10/2/96	1025	N/A	22.7	19.0	QCCS Standard	J Saavedra
10/2/96	940	N/A	38.1	20.7	Water Truck	J Saavedra
10/2/96	1045	N/A	38.8	20.6	Water Truck	J Saavedra
10/2/96	1045	980	46.8	20.5	Discharge Line	J Saavedra
10/2/96	1356	N/A	20.0	21.4	QCCS Standard	J Saavedra
10/2/96	1150	N/A	26.3	22.2	Water Truck	J Saavedra
10/2/96	1150	1000	38.4	21.2	Discharge Line	J Saavedra
10/2/96	1245	N/A	31.7	22.0	Water Truck	J Saavedra
10/2/96	1245	1015	35.6	21.0	Discharge Line	J Saavedra
10/2/96	1345	N/A	43.8	21.8	Water Truck	J Saavedra
10/2/96	1422	N/A	26.3	21.2	QCCS Standard	J Saavedra
10/2/96	1345	1030	31.1	21.3	Discharge Line	J Saavedra
10/2/96	1445	N/A	26.7	21.8	Water Truck	J Saavedra
10/2/96	1445	1045	32.9	20.5	Discharge Line	J Saavedra
10/2/96	1615	N/A	27.4	21.6	PT	J Saavedra
10/2/96	1615	1050	31.9	20.4	Discharge Line	J Saavedra
10/2/96	1759	N/A	29.4	19.9	QCCS Standard	J Saavedra
10/2/96	1635	N/A	27.8	20.9	PT	J Saavedra
10/2/96	1635	1060	32.6	20.4	Discharge Line	J Saavedra
10/2/96	1800	1063	30.1	21.5	Discharge Line	J Saavedra
10/2/96	2245	N/A	20.5	20.6	QCCS Standard	R. Peterson
10/2/96	1950	Purge at 106	31.7	19.8	Discharge Line	R. Peterson
10/2/96	2035	Purge at 106	30.1	20.7	Discharge Line	R. Peterson
10/2/96	2130	Purge at 106	ND <sup>b</sup> Lead	N/A	Discharge Line	R. Peterson
10/2/96	2145	Purge at 106	ND Lead	N/A	Discharge Line	R. Peterson
10/2/96	2125	N/A	20.0	21.9	Water Truck	R. Peterson
10/2/96	2135	N/A	18.2	20.9	QCCS Standard	R. Peterson
10/2/96	2215	Purge at 106	24.1	22.6	Discharge Line	R. Peterson

**Table 4-1**  
**Well HC-1 Lithium Bromide Concentrations**  
(Page 3 of 3)

Date mm/dd/yy	Time (24 hrs)	Depth (ft)	Sample Conc. (mg/L)	Sample Temp (C°)	Sample Source	Analysis By
10/2/96	2315	Purge at 106	20.4	22.7	Discharge Line	R. Peterson
10/3/96	15	Purge at 106	21.0	24.6	Discharge Line	R. Peterson
10/3/96	30	Purge at 106	22.3	21.3	Discharge Line	R. Peterson
10/3/96	30	Purge at 106	21.1	21.7	Discharge Line	R. Peterson
10/3/96	45	N/A	18.0	22.1	QCCS Standard	R. Peterson
10/3/96	2055	N/A	30.3	20.0	Water Truck	R. Peterson
10/3/96	2350	N/A	25.1	19.5	Discharge Line w/Foam	R. Peterson
10/4/96	45	N/A	23.3	19.3	Discharge Line w/Foam	R. Peterson
10/4/96	105	N/A	23.0	20.5	Discharge Line w/Foam	R. Peterson
10/4/96	120	N/A	25.2	20.2	Discharge Line	R. Peterson
10/4/96	135	N/A	25.7	20.6	Discharge Line	R. Peterson
10/4/96	150	N/A	21.1	20.7	QCCS Standard	R. Peterson
10/4/96	205	N/A	32.9	18.5	Water Truck	R. Peterson
10/4/96	205	N/A	25.7	20.7	Discharge Line	R. Peterson
10/4/96	215	N/A	18.4	24.4	QCCS Standard	R. Peterson
10/4/96	230	N/A	20.7	29.1	Discharge Line	R. Peterson
10/4/96	245	N/A	27.7	20.2	Discharge Line	R. Peterson
10/4/96	255	N/A	26.9	20.4	Discharge Line	R. Peterson
10/4/96	305	N/A	25.4	21.1	Discharge Line	R. Peterson
10/4/96	330	N/A	15.3(23.2) <sup>c</sup>	29.1(20.7) <sup>c</sup>	QCCS Standard	R. Peterson
10/4/96	523	N/A	25.8	19.4	Discharge Line	R. Peterson
10/26/96	940	N/A	20.3	25.3	QCCS Standard	P. Gallo
10/26/96	1000	N/A	37.0	25.1	Water Truck	P. Gallo
10/26/96	1000	1075	37.6	25.1	Discharge Line	P. Gallo
10/26/96	1030	N/A	29.3	25.0	Water Truck	P. Gallo
10/26/96	1030	1095	32.6	25.2	Discharge Line	P. Gallo
10/27/96	1207	N/A	19.8	25.1	QCCS Standard	M. Flaughter
10/27/96	1505	N/A	38.6	24.6	Water Truck	R. Peterson
10/27/96	1500	1123	38.1	25.1	Discharge Line	R. Peterson
10/27/96	1600	N/A	39.1	24.7	Water Truck	R. Peterson
10/27/96	1600	1155	29.5	25.0	Discharge Line	R. Peterson
10/27/96	1700	1203	36.1	24.8	Discharge Line	R. Peterson
10/27/96	2305	N/A	21.3	25.0	QCCS Standard	R. Peterson
10/27/96	1800	1223	43.3	24.8	Discharge Line	R. Peterson
10/27/96	1800	1223	N/D	LEAD	Discharge Line	R. Peterson
10/27/96	1830	1230	39.4	24.8	Discharge Line	R. Peterson
10/27/96	1920	1250	28.9	24.9	Discharge Line	R. Peterson
10/27/96	1955	1270	29.4	25.0	Discharge Line	R. Peterson
10/27/96	2340	N/A	20.8	25.0	QCCS Standard	R. Peterson
10/27/96	2025	1290	29.7	24.8	Discharge Line	R. Peterson
10/27/96	2100	1310	17.8	25.0	Discharge Line	R. Peterson
10/27/96	2125	1330	10.7	25.0	Discharge Line	R. Peterson
10/27/96	2150	N/A	38.5	25.0	Water Truck	R. Peterson
10/27/96	2250	1343	5.68	25.0	Discharge Line	R. Peterson
10/27/96	2400	N/A	20.9	24.5	QCCS Standard	R. Peterson
10/28/96	1200	N/A	20.3	24.2	QCCS Standard	R. Peterson
10/28/96	1200	1343	2.71	24.4	Discharge Line	R. Peterson

<sup>a</sup>Not Applicable

<sup>b</sup>Indicates non-detect for lead.

<sup>c</sup>Sample was analyzed a second time at the temperature of 20.7 °C and the concentration was 23.2 mg/L.

**Table 4-2**  
**Well HC-1 Water Level Measurements**

Well Name	Date	Depth to Fluid (ft)	Elevation (ft)	Notes
HC-1	01-Oct-96	717.14	4592.07	Water level from depth to water check with drill pipe. Depth of well at this point is 783.0 ft.
HC-1	05-Oct-96	942	4367.21	Fluid level obtained from Century geophysics neutron log.
HC-1	08-Oct-96	920	4389.21	Fluid level DRI with tape. Accuracy not considered good.
HC-1	09-Oct-96	956	4353.21	Water level determined to top of casing using DRI down hole video camera.
HC-1	14-Oct-96	959.1	4350.11	Fluid level determined from DRI transducer installed well.
HC-1	15-Oct-96	962	4347.21	Fluid level determined via DRI transducer in well. Measured to ground level (GL).
HC-1	16-Oct-96	964.72	4344.49	Depth to water obtained from DRI transducer set in well. Measured to GL.
HC-1	21-Oct-96	975.99	4333.22	DRI transducer reading to top of conductor casing, approx. 1 ft above GL. Value adjusted to GL.
HC-1	22-Oct-96	977.11	4332.1	DRI transducer reading adjusted for ground level.
HC-1	23-Oct-96	978.91	4330.3	DRI transducer reading. Measured to top of conductor casing, at 1 ft above GL.
HC-1	29-Oct-96	1081.71	4227.5	Water level obtained by IT Corp. using solinist tape.
HC-1	01-Nov-96	1079	4230.21	DRI water level obtained from top of surface casing, stick-up approx. 1 ft. Value adjusted to GL.
HC-1	13-Nov-96	1078	4231.21	Water level approx. obtained from the DRI down hole video camera measured to GL.

**Table 4-3**  
**Well HC-1 List of Geophysical Logs**

<b>Well Name</b>	<b>Geophysical Log</b>	<b>Date Logged</b>	<b>Log Top (ft)</b>	<b>Log Bottom (ft)</b>	<b>Logging Company</b>
HC-1	3-Arm Caliper	10/5/96	0.00	902.70	Century Geophysical
HC-1	3-Arm Caliper	11/6/96	1014.10	1323.80	Century Geophysical
HC-1	3-Arm Caliper	9/9/96	915.00	1028.00	DRI
HC-1	Density/Resistivity/Neutron/Neutron Porosity	10/5/96	0.00	1030.90	Century Geophysical
HC-1	Density/Resistivity/Neutron/Neutron Porosity	11/6/96	1003.10	1324.90	Century Geophysical
HC-1	Deviation - magnetic	10/6/96	0.10	1028.70	Century Geophysical
HC-1	Deviation - gyroscopic	11/7/96	0.60	1326.00	Century Geophysical
HC-1	Spectra Gamma Ray (K, U, Th)	10/5/96	1.90	1028.50	Century Geophysical
HC-1	Spectra Gamma Ray (K, U, Th)	11/6/96	1015.90	1324.00	Century Geophysical
HC-1	Temperature	10/5/96	625.50	1029.30	Century Geophysical
HC-1	Temperature	11/6/96	915.90	1324.60	Century Geophysical
HC-1	Acoustic Borehole Televiewer	11/6/96	1099.24	1324.25	Century Geophysical
HC-1	Chemtool	11/14/96	1082.00	1327.00	DRI
HC-1	Downhole Video Camera	10/4/96	0.00	889.00	DRI

Note: Calibrations and repeat sections were performed per contract specifications.

**Table 4-4**  
**HC-1 Summary of Subsurface Investigation Samples**

Sample Number	Date Collected	Location	Sample Type	Depth (ft)	COC Number <sup>a</sup>	Comments
PSC00001	10/2/96	HC-1	Cuttings	930	519811	Cuttings sample collected at HC-1 during drilling.
PSW00003	10/4/96	HC-1	Groundwater	920	519812	Groundwater sample from HC-1 Well Development...Full Lab QC
PSW00004	10/4/96	HC-1	Groundwater (dup)	920	519812	Duplicate of sample PSW00003
PSW00005	10/4/96	HC-1	Water (QC)	NA	519812	Equipment Rinsate sample
PSW00006	10/4/96	HC-1	Water (QC)	NA	519812	Field Blank sample
PSF00001	10/5/96	HC-1	Discharge Fluid	NA	519816	Composite sample collected at HC-1 Sump #1
PCX00001	11/3/96	HC-1	2nd Discharge Fluid	NA	519820	Additional fluids discharged into HC-1 Sump #1, 2nd composite sample collected.
PSC00002	10/16/96	HC-2	Cuttings	1253	519813	Cuttings sample from HC-2 taken during drilling.
PSW00007	10/21/96	HC-2	Groundwater	1173	519814	Groundwater sample from HC-2 Well Development.
PSF00003	10/20/96	HC-2	Discharge Fluid	NA	522037	Composite sample collected at HC-2 Sump #1.
PSC00003	11/5/96	HC-3	Cuttings	1255	519822	Cuttings sample from HC-3 taken during drilling.
PSW00008	11/14/96	HC-3	Groundwater	1104	519823	Groundwater sample from HC-3 Well Develop. Waiting on results.
PSF00005	11/12/96	HC-3	Discharge Fluid	NA	519824	Composite sample collected at HC-3, Sump #1.
PSC00004	10/23/96	HC-4	Cuttings	1250	519817	Cuttings sample collected at HC-4 during drilling.
PSW00009	11/7/96	HC-4	Groundwater	1130	519819	Groundwater sample from HC-4 using a discrete bailer.
PSF00007	10/24/96	HC-4	Discharge Fluid	NA	519818	Composite sample collected at HC-4, Sump #1

<sup>a</sup>Chain of Custody

**Tables 4-5a to 4-5e**  
**HC-1 Sample Results**  
 (Page 1 of 3)

**Table 4-5a**

Sample Location	Sample #	Sample Date	Matrix	Aluminum (mg/L) <sup>a</sup>	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)
HC-1	PSC00001	10/2/96	Cuttings	N/A <sup>b</sup>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00003	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00004	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSF00001	10/5/96	Sump	1.19	0.0272 (ND) <sup>c</sup>	0.0086	0.0526	0.0004	0.408	0.003 (ND)	38.5	0.0044 (ND)
HC-1	PSX00001	11/3/96	Sump	N/A	N/A	0.0026	0.16	N/A	N/A	0.0006 (ND)	N/A	0.011
HC-1	PSW00005	10/4/96	Water (QC)	N/A	N/A	ND <sup>d</sup>	ND	N/A	N/A	ND	N/A	ND
HC-1	PSW00006	10/4/96	Water (QC)	N/A	N/A	N/A	ND	N/A	N/A	N/A	N/A	ND

**Table 4-5b**

Sample Location	Sample #	Sample Date	Matrix	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Lithium (mg/L)	agnesi (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
HC-1	PSC00001	10/2/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00003	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00004	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSF00001	10/5/96	Sump	0.003 (ND)	0.01	2.01	0.0013	1.8	4.92	0.154	0.0001 (ND)	0.0199
HC-1	PSX00001	11/3/96	Sump	N/A	N/A	N/A	0.0046	N/A	N/A	N/A	0.0001 (ND)	N/A
HC-1	PSW00005	10/4/96	Water (QC)	N/A	N/A	N/A	ND	N/A	N/A	N/A	ND	N/A
HC-1	PSW00006	10/4/96	Water (QC)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit.

<sup>d</sup>Not detected

<sup>e</sup>Units in PicoCuries per liter (pCi/L) unless otherwise noted

<sup>f</sup>PicoCurie per gram

**Tables 4-5a to 4-5e**  
**HC-1 Sample Results**  
 (Page 2 of 3)

**Table 4-5c**

Sample Location	Sample #	Sample Date	Matrix	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Strontium (mg/L)	Thallium (mg/L)
HC-1	PSC00001	10/2/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00003	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSW00004	10/4/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-1	PSF00001	10/5/96	Sump	0.0134 (ND)	8.23	0.004	17.9	0.0066 (ND)	56.2	0.466	0.0035 (ND)
HC-1	PSX00001	11/3/96	Sump	N/A	N/A	0.0043	N/A	0.0015 (ND)	N/A	N/A	N/A
HC-1	PSW00005	10/4/96	Water (QC)	N/A	N/A	ND	N/A	ND	N/A	N/A	N/A
HC-1	PSW00006	10/4/96	Water (QC)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

**Table 4-5d**

Sample Location	Sample #	Sample Date	Matrix	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	Tritium (pCi/L) <sup>e</sup>	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Bismuth-214 (pCi/L)	Cesium-137 (pCi/L)
HC-1	PSC00001	10/2/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	ND pCi/g <sup>f</sup>	0.14 pCi/g (ND)
HC-1	PSW00003	10/4/96	Groundwater	N/A	N/A	N/A	-3	43.9	24.6	ND	3.89 (ND)
HC-1	PSW00004	10/4/96	Groundwater	N/A	N/A	N/A	8	36.4	18.3	ND	7.58 (ND)
HC-1	PSF00001	10/5/96	Sump	0.127 (ND)	0.0031 (ND)	0.033	22	4.5	9.64	ND	ND
HC-1	PSX00001	11/3/96	Sump	N/A	N/A	N/A	-2	14.2	8.11	ND	ND
HC-1	PSW00005	10/4/96	Water (QC)	N/A	N/A	N/A	21	1.62	0.91	ND	5.15 (ND)
HC-1	PSW00006	10/4/96	Water (QC)	N/A	N/A	N/A	27	0.43	0.06	ND	4.35 (ND)

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit.

<sup>d</sup>Not detected

<sup>e</sup>Units in PicoCuries per liter (pCi/L) unless otherwise noted

<sup>f</sup>PicoCurie per gram

**Tables 4-5a to 4-5e**  
**HC-1 Sample Results**  
 (Page 3 of 3)

**Table 4-5e**

Sample Location	Sample #	Sample Date	Matrix	Lead-212 (pCi/L)	Potassium-40 (pCi/L)	Thallium-208 (pCi/L)
HC-1	PSC00001	10/2/96	Cuttings	0.26 pCi/g	28.9 pCi/g	ND pCi/g
HC-1	PSW00003	10/4/96	Groundwater	ND	107	ND
HC-1	PSW00004	10/4/96	Groundwater	ND	153	ND
HC-1	PSF00001	10/5/96	Sump	ND	ND	ND
HC-1	PSX00001	11/3/96	Sump	ND	ND	ND
HC-1	PSW00005	10/4/96	Water (QC)	ND	ND	ND
HC-1	PSW00006	10/4/96	Water (QC)	ND	ND	ND

4-24

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit.

<sup>d</sup>Not detected

<sup>e</sup>Units in PicoCuries per liter (pCi/L) unless otherwise noted

<sup>f</sup>PicoCurie per gram

## **5.0 Well HC-2 Summary of Operations**

---

Well HC-2 was drilled to a depth of 397.15 m (1,303.0 ft) between October 5, 1996, and October 15, 1996. A total of eight days was spent drilling and completing installation of this well. Note that [Figures 5-1 through 5-10](#) and [Tables 5-1 through 5-5](#), cited in the following text, are located at the end of this section.

Prior to mobilization, all drilling equipment was decontaminated at the on-site decontamination pad using a combination of steam cleaning and high pressure washing. Decontaminated equipment was subjected to a radiological screening prior to movement to the drill site.

A 30.48-cm (12.0-in.) surface conductor casing hole was drilled using air rotary reverse circulation and a downhole percussion hammer to a depth of approximately 13.72 m (45.0 ft). Due to its deviated condition, this hole was abandoned and cemented to the surface. A second 30.48-cm (12.0-in.) conductor hole was drilled approximately 3.05 m (10.0 ft) east of the first location and successfully completed to a depth of 31.0 m (101.7 ft) bgs. A 21.91-cm (8.625-in.) conductor casing was installed within the hole and cemented with Type II cement with 2 percent calcium chloride additive from the TD of the hole to the ground surface.

The main hole was drilled to a depth of approximately 76.20 m (250.0 ft) bgs using a 20.32-cm (8.0-in.) downhole percussion hammer assembly and air rotary reverse circulation drilling techniques. Upon initial drilling of the main hole, the drilling subcontractor, Belik Drilling, developed problems with the rig-mounted air compressor. Operations were suspended for approximately one day to repair the air compressor. Repairs to the primary rig compressor could not be completed, and a portable compressor was delivered to the site to supply air for drilling. This compressor developed a severe oil leak after several hours of operation, and site operations were again suspended for a period of five days between October 9, 1996, and October 14, 1996, to allow for repair of the air compressors and other malfunctioning equipment associated with the drilling.

On October 14, 1996, drilling operations resumed on the HC-2 drill site. Drilling proceeded at a steady rate to a TD of 397.15 m (1,303.0 ft) bgs. [Figure 5-1](#) provides a summary of drilling parameters for the well. All figures and tables cited in the text are located at the end of this section.

Well development using reverse circulation techniques was conducted on October 16, 1996, following the drilling of the well. Upon completion of well development, drill pipe was pulled from the well to allow for geophysical logging operations. The geophysical logging subcontractor, Century Geophysical, was unable to reach the TD of the well due to an obstruction in the borehole at a depth of 267.61 m (878.0 ft) bgs. The 20.32-cm (8.0-in.) drilling assembly with a tricone button bit was tripped back in the hole to clear the obstruction and to clean the hole to the TD of the well. Unstable, sloughing borehole conditions resulted in obstructions occurring at depths of 231.65, 319.43, and 347.47 m (760.0, 1,048.0, and 1,140.0 ft) bgs. Two separate attempts were required to clear and clean the borehole in preparation for geophysical logging. Prior to logging, a sinker bar was run into the hole to establish whether any blockages had developed. The sinker bar was unable to pass below a depth of 268.22 m (880.0 ft) bgs. It was determined that geophysical logging of the available open borehole should be conducted. Century Geophysical and DRI completed the logging of the well to the obstructed depth of 268.22 m (880.0 ft) on October 18, 1996.

Intermediate (13.97-cm [5.5-in.]) casing was installed in the well to a depth of 291.69 m (957 ft) bgs upon completion of geophysical logging operations. The intermediate casing needed to be drilled down through obstructed portions of the borehole at approximately 268.22 m (880.0 ft). The hole was then reentered using reverse circulation drilling techniques and an 11.75-cm (4.625-in.) tricone bit to clean out the obstructed borehole below the final casing point. The hole was cleaned and conditioned to a depth of 396.24 m (1,300.0 ft), at which point the drill pipe was pulled from the hole in preparation for geophysical logging operations.

Geophysical logging was then conducted to a depth of 373.08 m (1,224.0 ft) bgs, at which point the borehole was once again obstructed. The water level in the well at this time was noted at 343.77 m (1,127.85 ft) bgs. It was then determined by DRI that the well provided an interval of 36.57 m (120 ft) between 336.16 to 372.77 m (1,102.9 to 1,223.0 ft) of open borehole within the saturated zone, which was determined to be sufficient to facilitate the planned scientific studies.

### **5.1 Well HC-2 Geology**

Well HC-2 encountered principally a fractured, coarse-grained, biotite granite of Cretaceous age throughout the drilled interval. An intrusive aplite dike was noted in the interval between 137.16 and 152.40 m (450 and 500 ft). Significant fault/fracture zones were apparent in the approximate intervals between 134.11 to 152.40 m (440.0 to 500.0 ft), 176.78 to 192.02 m (580.0 to 630.0 ft), 252.98 to 257.56 m (830.0 to 845.0 ft), and 335.28 to 341.38 m (1,100.0 to 1,120.0 ft). A detailed description of the lithologies encountered in the well is provided in [Figure 5-2](#).

## **5.2 Well HC-2 Hydrology**

Several elements of hydrologic importance were monitored during and after the completion of the well. During drilling operations, two monitoring parameters were consistently compared: the volume of drilling fluids (water) injected to facilitate drilling and the recorded volumes of fluid produced as discharge to the surface during the same time. [Figure 5-3](#) illustrates the relationships between injected drilling fluids and drilling fluid produced at the surface. In addition to these volumetric measurements, all drilling fluids injected into the borehole were tagged with a tracer solution of Lithium Bromide (LiBr). The concentration of this solution was monitored on a regular basis to estimate groundwater production within the borehole. [Table 5-1](#) illustrates LiBr concentrations noted in produced fluids.

Water production from the well was minimal; monitoring data and water level recovery data suggests the well was capable of producing approximately 0.75 to 1.0 gpm (2.8 to 3.8 L/min). During several instances, the well was capable of intermittent production on the order of 3.0 to 5.0 gpm (11.4 to 18.9 L/min). These readings suggest production from perched water zones along fault or fracture zones. These zones were of limited impact as their storage capacity was exhausted, and their contribution to the well decreased.

Water-level monitoring was conducted during the construction of the well and continued after completion using transducers set by DRI. [Table 5-2](#) provides water levels obtained for the term of IT involvement in PSA field work.

## **5.3 Well HC-2 Geophysical Surveys**

A suite of downhole geophysical surveys was run within the borehole upon completion of drilling to the TD of 397.15 m (1,303.0 ft) after a phase of well development. Due to unstable borehole conditions, geophysical logging was conducted in two separate phases. The first phase consisted of logging by both Century and DRI to a depth of approximately 259.08 m (850.0 ft) bgs. Upon completion of these logging runs, intermediate casing was installed in the well to a depth of 291.69 m (957.0 ft) bgs. After casing installation, the well was logged from a point below the casing to the well's accessible total depth of 373.08 m (1,224.0 ft) bgs. The portion of the borehole from 259.08 to 291.69 m (850.0 to 957.0 ft) was not logged due to obstruction of the borehole at 259.08 m (850.0 ft) and to the installation of intermediate casing to a depth of 291.69 m (850.0 ft) bgs.

Deviation surveys conducted within the casing and borehole indicate the borehole is deviated 2.7 degrees from vertical in a north-northeast direction. The deviation of the hole placed the

bottom of the hole 4.88 m (16.0 ft) north-northeast of the collar and resulted in a true vertical depth of 369.97 m (1,213.81 ft) bgs.

[Table 5-3](#) provides a summary of the geophysical logs run for the well. Additional specialized logging was performed by DRI as part of their scientific work scope. [Figures 5-4 to 5-7](#) provide condensed illustrations of log traces for well HC-2.

#### **5.4 Well HC-2 Radiologic Monitoring**

Monitoring of discharge effluent from drilling was conducted as specified in the Project Shoal SSHASP (DOE/NV, 1996b) and the FMP for the Project Shoal Area Offsite Subproject (DOE/NV, 1996c). Regular radiological monitoring of discharged drilling effluents, including both fluids and solids, was conducted by Bechtel Nevada radiation control technicians. Samples for further analysis were screened using handheld instruments at the time of collection. Effluents were then further analyzed for tritium and other radionuclides using on-site laboratory monitoring equipment. Tritium activities from fluid and swiped samples were recorded using a Packard Liquid Scintillation instrument. Other radionuclides were analyzed using Canberra gamma spectroscopy instrumentation.

Well HC-2 effluents were found to contain only natural background levels of tritium and other radionuclides based on results of field monitoring. [Figure 5-8](#) is a profile of tritium encountered in fluids produced from the well.

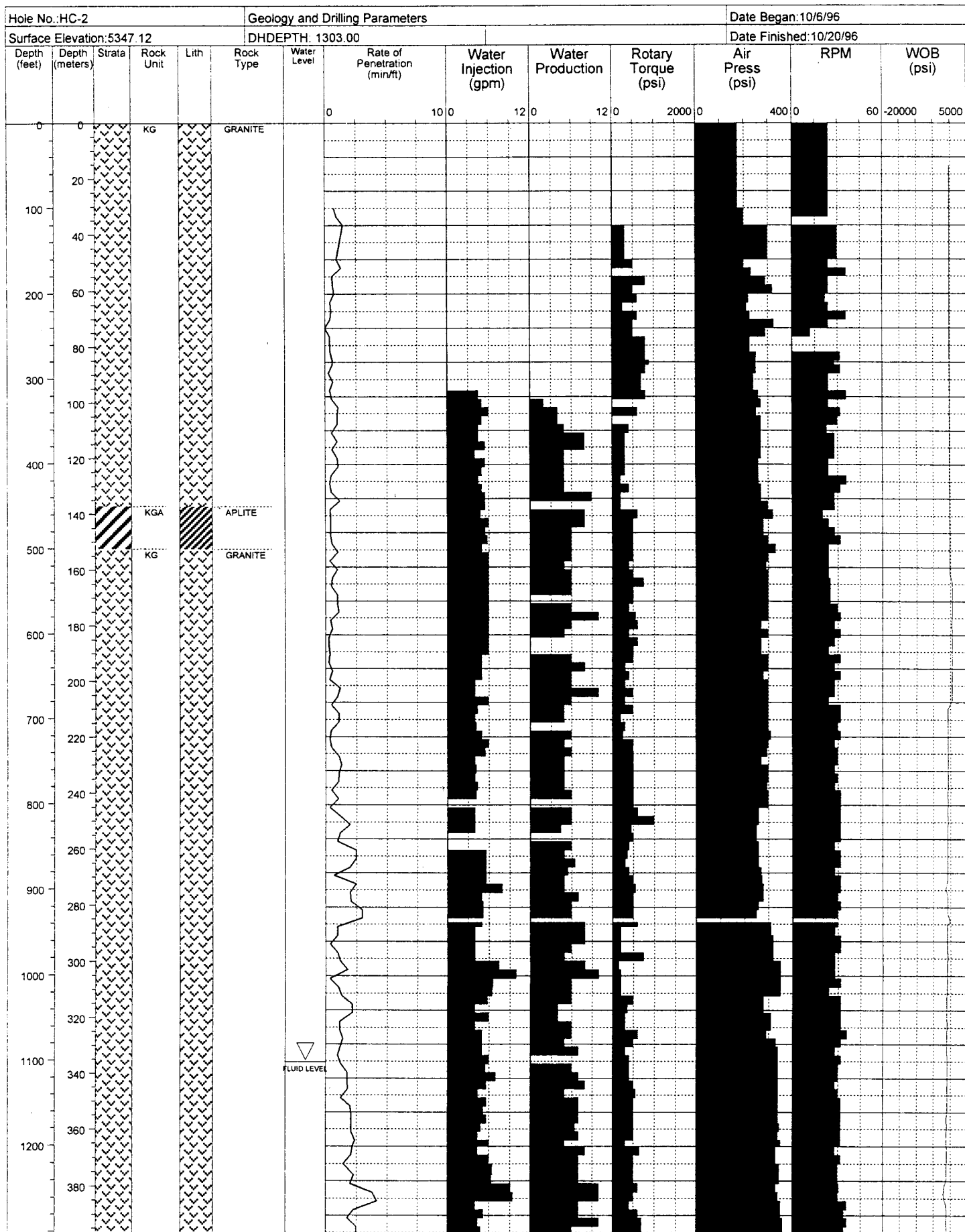
#### **5.5 Well HC-2 Well Construction**

Final construction of Well HC-2 included the drilling of a 30.48-cm (12.0-in.) surface borehole to a depth of 31.39 m (103 ft). Conductor casing comprised of 21.91-cm (8.625-in.) carbon steel was installed in the 30.48-cm (12.0-in.) hole. Bow type centralizers were placed approximately 1.52 m (5.0 ft) from the bottom of the casing. Conductor casing was cemented to the surface using Type II cement with 2 percent calcium chloride as an additive. An 30.32-cm (8.0-in.) borehole was drilled to a TD of 397.15 m (1,303.0 ft) bgs beneath the conductor casing.

Intermediate, 13.97-cm (5.50-in.) carbon steel casing was installed in the completed borehole and set at a depth of 291.08 m (955.0 ft) bgs. Intermediate casing was installed without centralizers or cement baskets due to adverse borehole conditions; casing was then suspended on landing straps secured to the surface conductor casing. [Figure 5-9](#) provides a schematic view of the final completion. The surface completion for the well head is illustrated in [Figure 5-10](#).

## **5.6 Well HC-2 Sampling**

Samples for analytical analysis were collected from fluids and cuttings as specified in the *Field Instructions for Project Shoal Area Surface and Subsurface Investigation, Churchill County, Nevada* (IT, 1996) and the FMP for the Project Shoal Area Offsites Subproject (DOE/NV, 1996c). The sample type and analytical results of these samples are shown in [Tables 5-4 and 5-5](#).



Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

Figure 5-1

# Summary of Well HC-2 Drilling Parameters

IT CORPORATION

Project Shoal

Project No. 764044.03.07.00.00

Shoal Project  
Churchill Co Nevada  
Project No. 764044.03.07.00.00  
IT Corporation Offsites Project  
Lithologic Descriptions by Well

Well ID. HC-2 GRANITE 0.00 30.00 jaw 10/08/96  
Granite, mottled grayish white to yellowish white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%)

Well ID. HC-2 GRANITE 30.00 60.00 jaw 10/08/96  
Granite, bleached grayish white to mottled yellowish white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%). Abundant limonite staining and weak coating on fracture surfaces. Fracture zone and rubbly cuttings noted in the interval 30-60 ft. Minor water production noted in the same interval. Good cuttings quality 2.0-3.5mm, large cuttings 20-30 mm within the fractured interval.

Well ID. HC-2 GRANITE 60.00 200.00 jaw 10/14/96  
Granite, mottled grayish white to yellowish white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%)

Well ID. HC-2 GRANITE 200.00 310.00 jaw 10/14/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Spotty fracture stains of ocherous yellow orange limonite through out interval

Well ID. HC-2 GRANITE 310.00 450.00 jaw 10/14/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 10 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Spotty fracture stains of ocherous yellow orange limonite through out interval

Well ID. HC-2 APLITE 450.00 500.00 jaw 10/14/96  
Aplite, grayish white to milky grayish white, abundant quartz 85% as translucent to partly clear anhedral xls, microcline (15%) as cleaved xls Minor black to dark green biotite as <1.0 mm subhedral xls, possibly as residual cross contamination from other interval encountered above.

Well ID. HC-2 GRANITE 500.00 650.00 jaw 10/15/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xl altering locally to chlorite also noted as irregular masses to 5 mm (10%) apparently related to thin irregular schlieren type flowage features, groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%). Accessory magnetite and some specularite noted <1%. Locally spotty fracture stains of ocherous yellow orange limonite through out interval

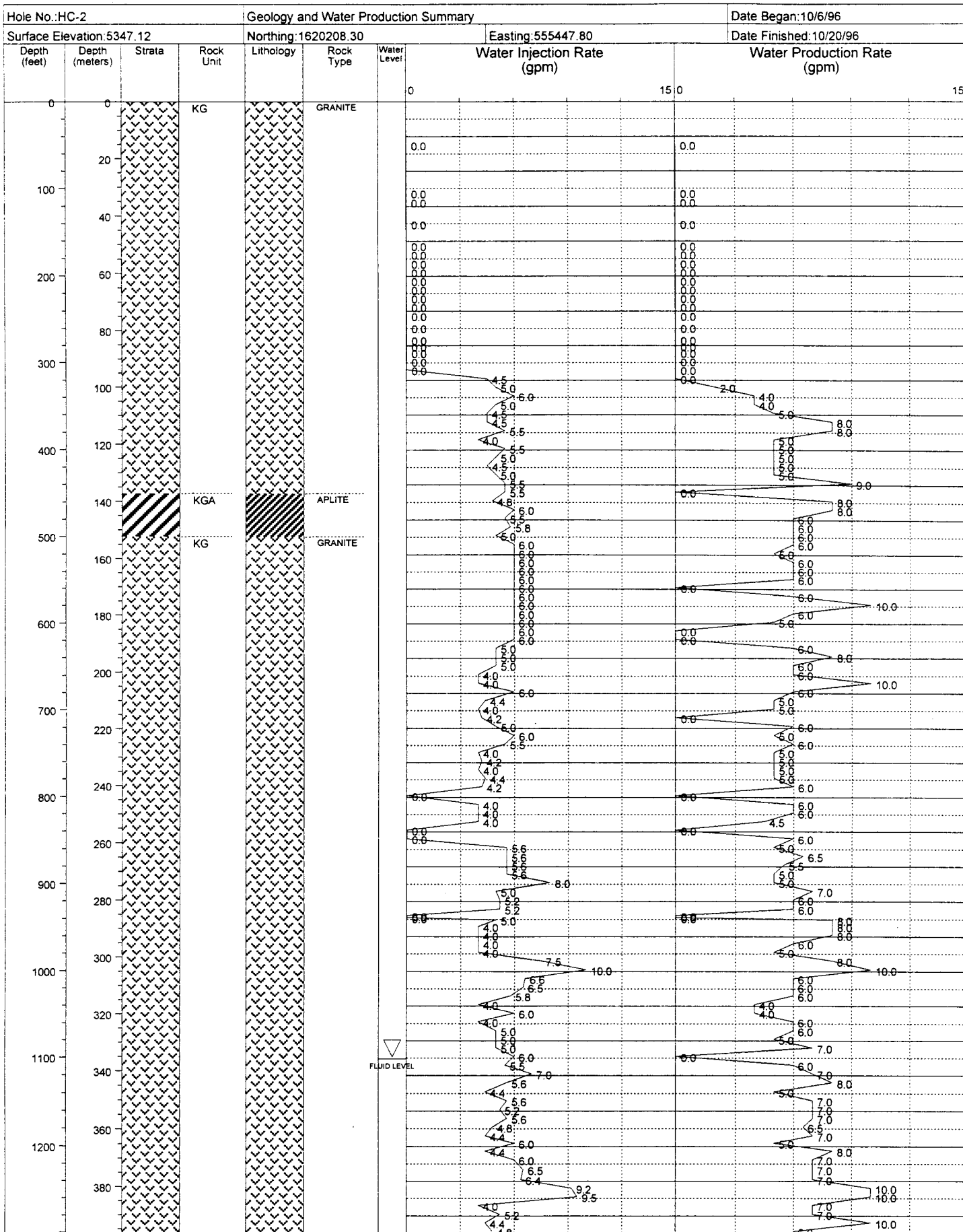
Well ID. HC-2 GRANITE 650.00 880.00 jaw 10/15/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite subhedral - euhedral xl (1.0-2.0 mm) altering locally to chlorite also noted as irregular masses to 5 mm (10%), groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspar (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Some accessory magnetite and specularite <1% noted. Locally spotty fracture stains of ocherous yellow orange limonite through out interval. Possible fracture zone 740-750 ft.

Figure 5-2  
Well HC-2 Lithologic Descriptions  
(Page 1 of 2)

Well ID. HC-2                      GRANITE                      880.00 1023.00      jaw 10/15/96  
 Granite, mottled grayish green white to buff light grayish green to medium gray green, porphyritic, abundant black to greenish black biotite subhed-euhed xl (1.0-2.0 mm) much altered locally to chlorite also noted as irregular masses to 5 mm (10%), apparent schlieren flowage as streaky masses of very fine grained chlorite with minor biotite as platy to lens like cuttings, groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspars (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Accessory magnetite and specularite < 1% noted. Locally spotty fracture stains of ochreous yellow orange limonite through out interval. Possible schlieren/fracture zones 900-930, 960-990 ft. Cuttings quality is generally good 1.0-4.0 mm and noticeably larger 10.0-15.0 mm in noted fracture zones.

Well ID. HC-2                      GRANITE                      1023.00 1303.00      jaw 10/15/96  
 Granite, mottled grayish green white to buff light grayish green to medium gray green, porphyritic, abundant black to greenish black biotite subhed-euhed xl (1.0-2.0 mm) much altered locally to chlorite also noted as irregular masses to 5 mm (10%), apparent schlieren flowage as streaky masses of very fine grained chlorite with minor biotite as platy to lens like cuttings, groundmass comprised of medium to coarse grained clear to milky quartz, (30%), milky white kspars (40%) also noted as porphyritic xl up to 5mm (20%), minor plagioclase (<10%) Accessory magnetite and specularite < 1% noted. Locally very spotty fracture stains of ochreous yellow orange limonite noted in isolated 10 ft. intervals. Possible schlieren/fracture zones 1090-1100, 1120-1130, 1140-1160 ft. Cuttings quality is generally good 1.0-4.0 mm and noticeably larger 10.0-15.0 mm in noted fracture zones.

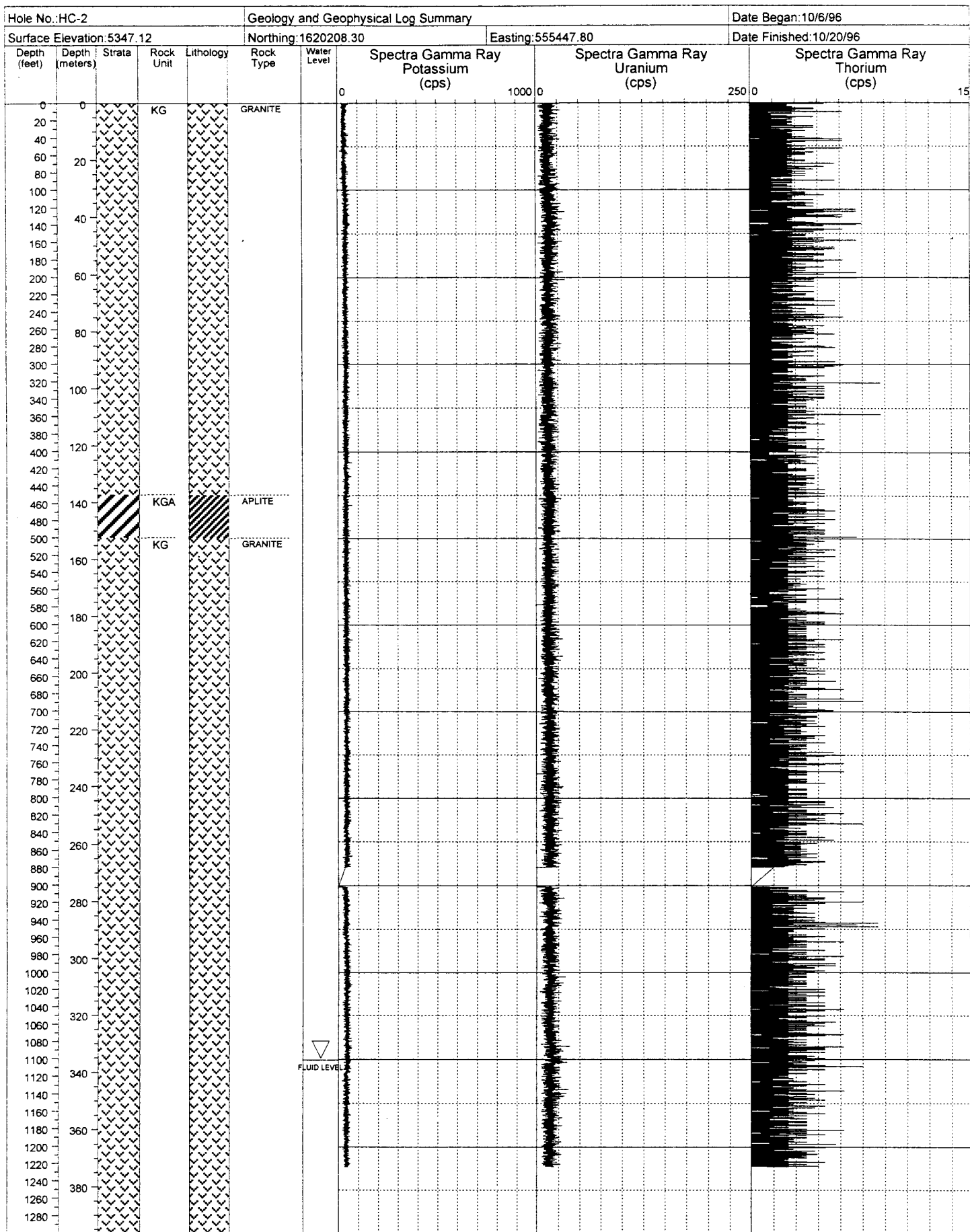
**Figure 5-2**  
**Well HC-2 Lithologic Descriptions**  
 (Page 2 of 2)



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

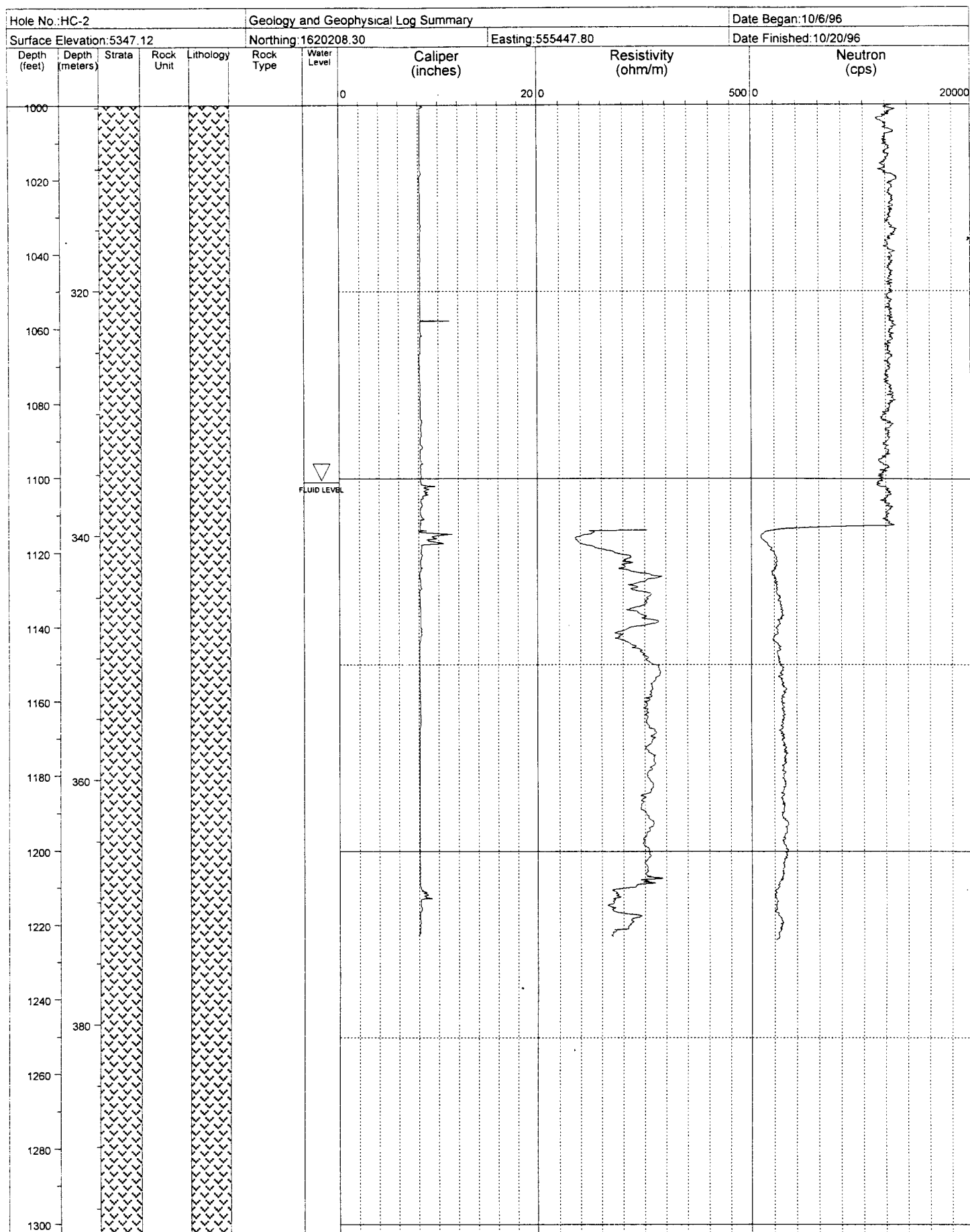
**Figure 5-3**  
**HC-2 Fluid Injection versus Production Diagram**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

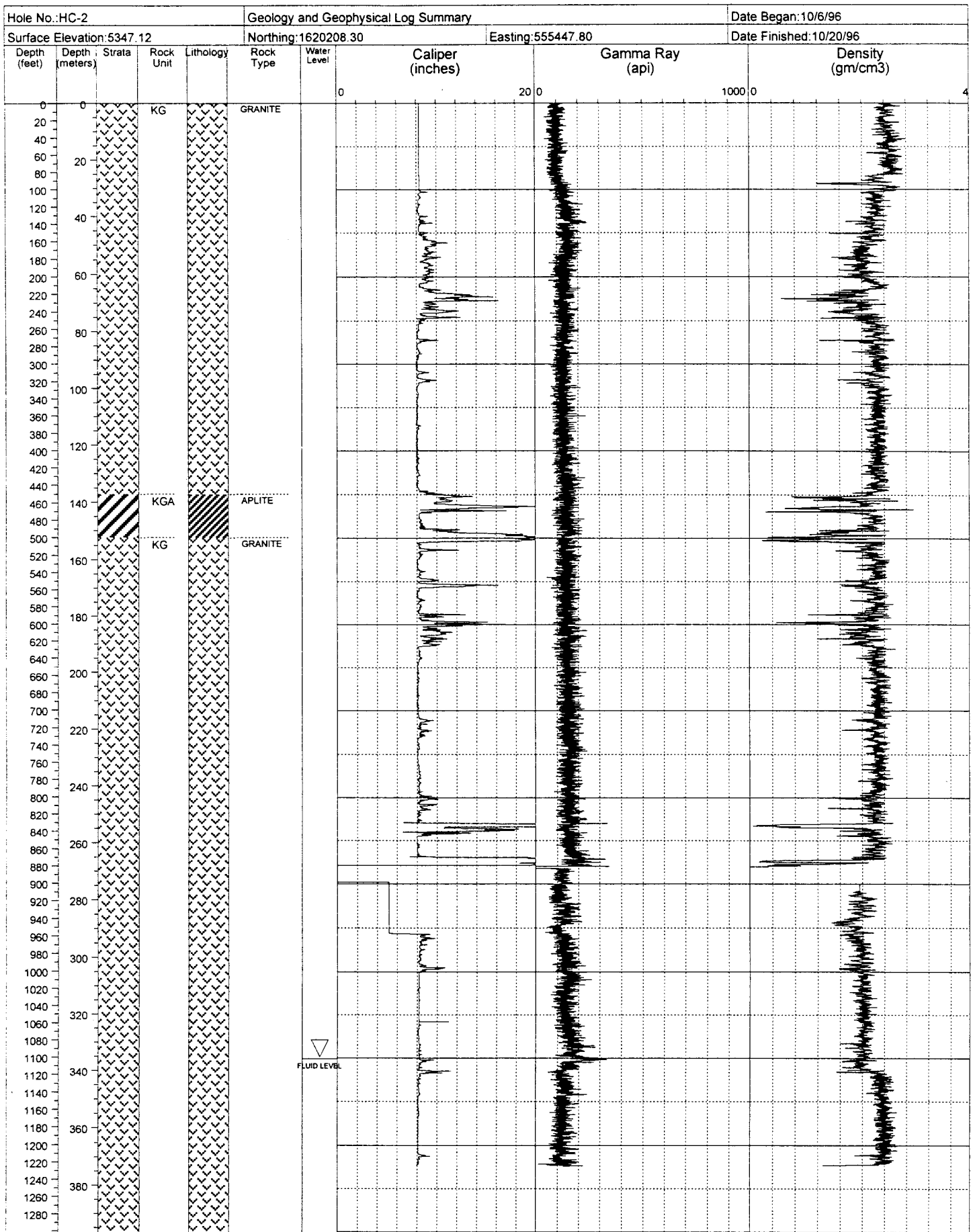
**Figure 5-4**  
**HC-2 Geophysical Log Traces of Spectra Gamma Ray**



Logged By: Century Geophysics/DRI  
Drilling Co.: Beylik Drilling Services  
Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
Project Shoal  
Project No. 764044.03.07.00.00

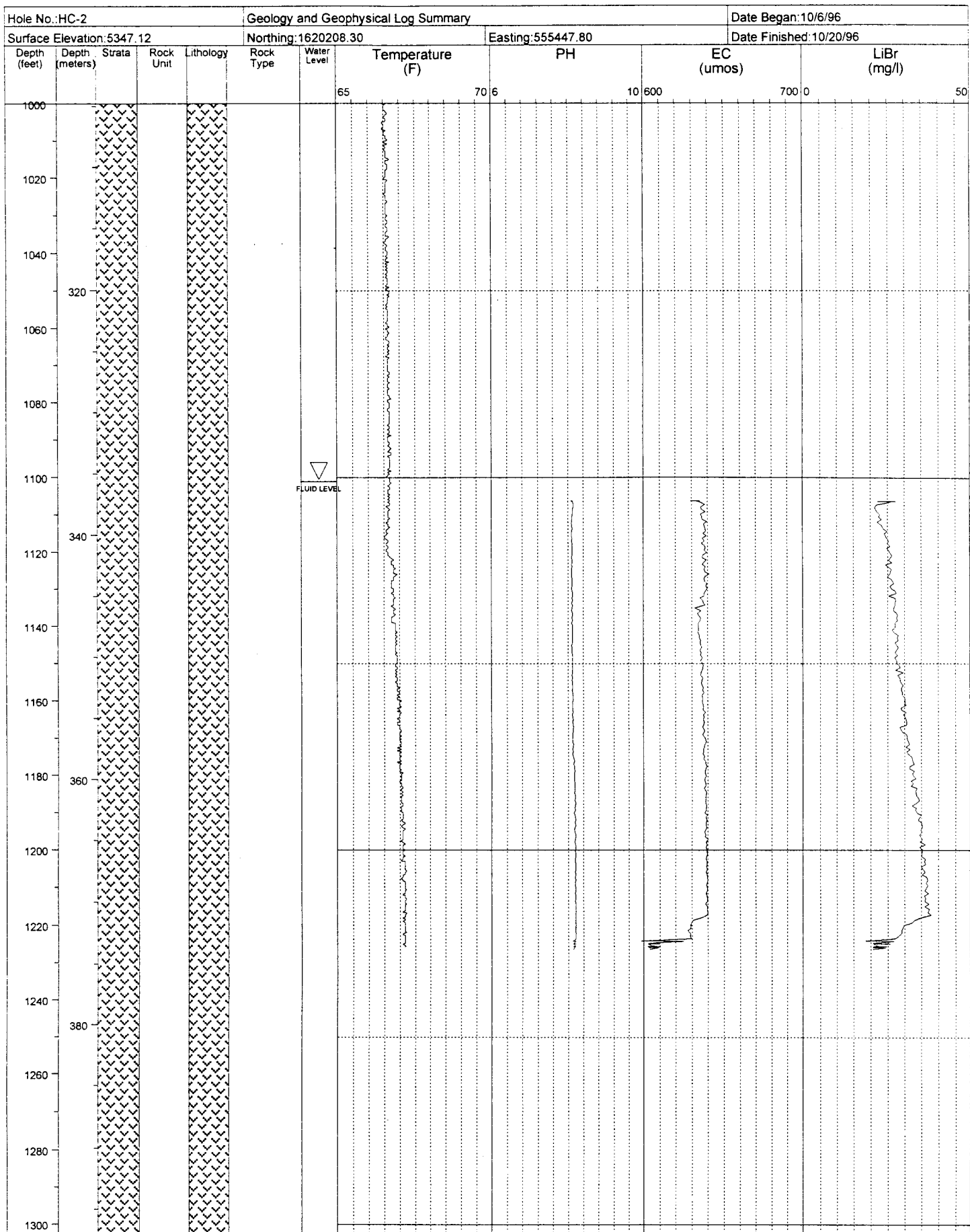
**Figure 5-5**  
**HC-2 Geophysical Log Traces of Caliper, Resistivity, Neutron**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

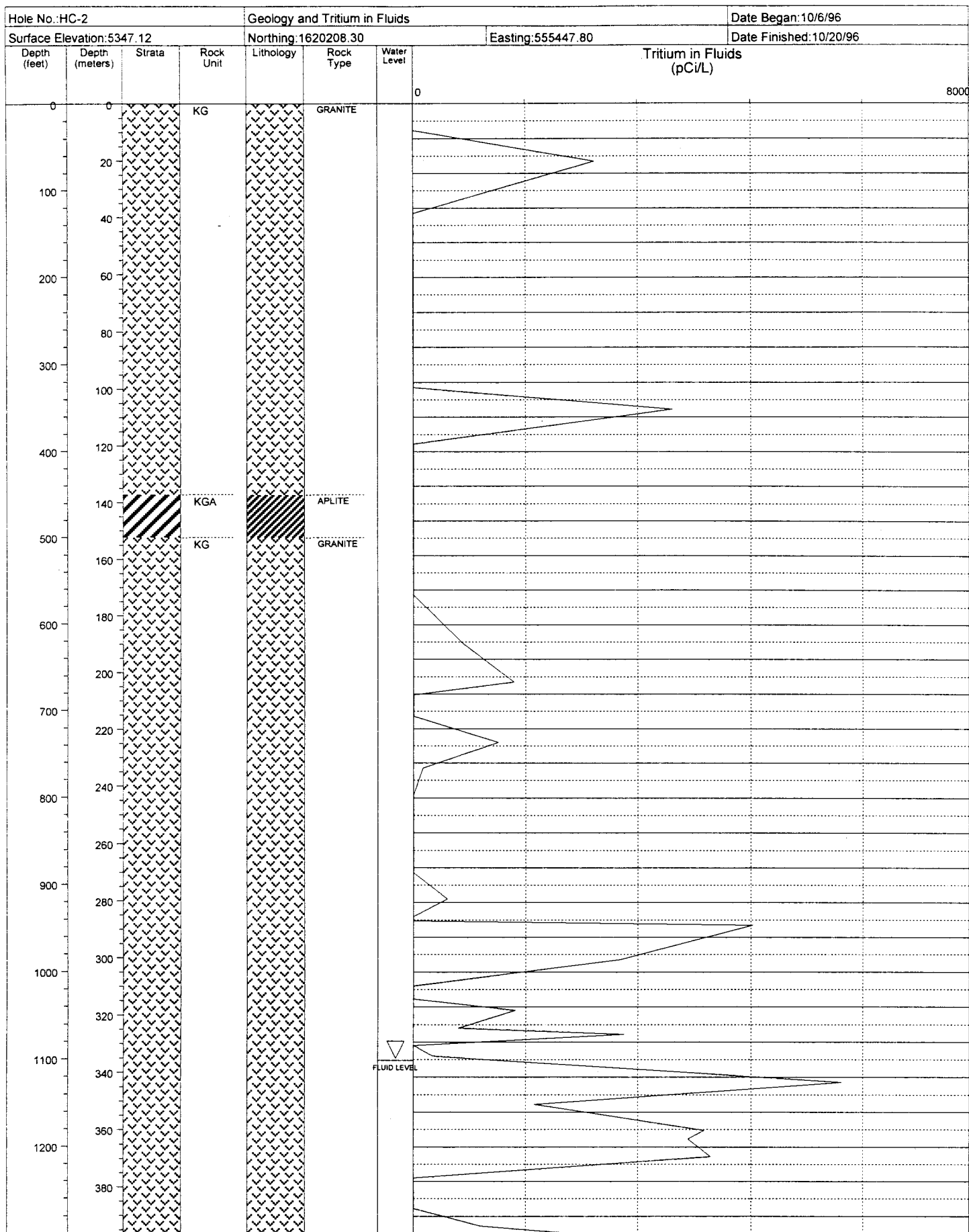
**Figure 5-6**  
**HC-2 Geophysical Log Traces of Caliper, Gamma Ray, Density**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 5-7**  
**HC-2 Geophysical Log Traces of Chemtool**

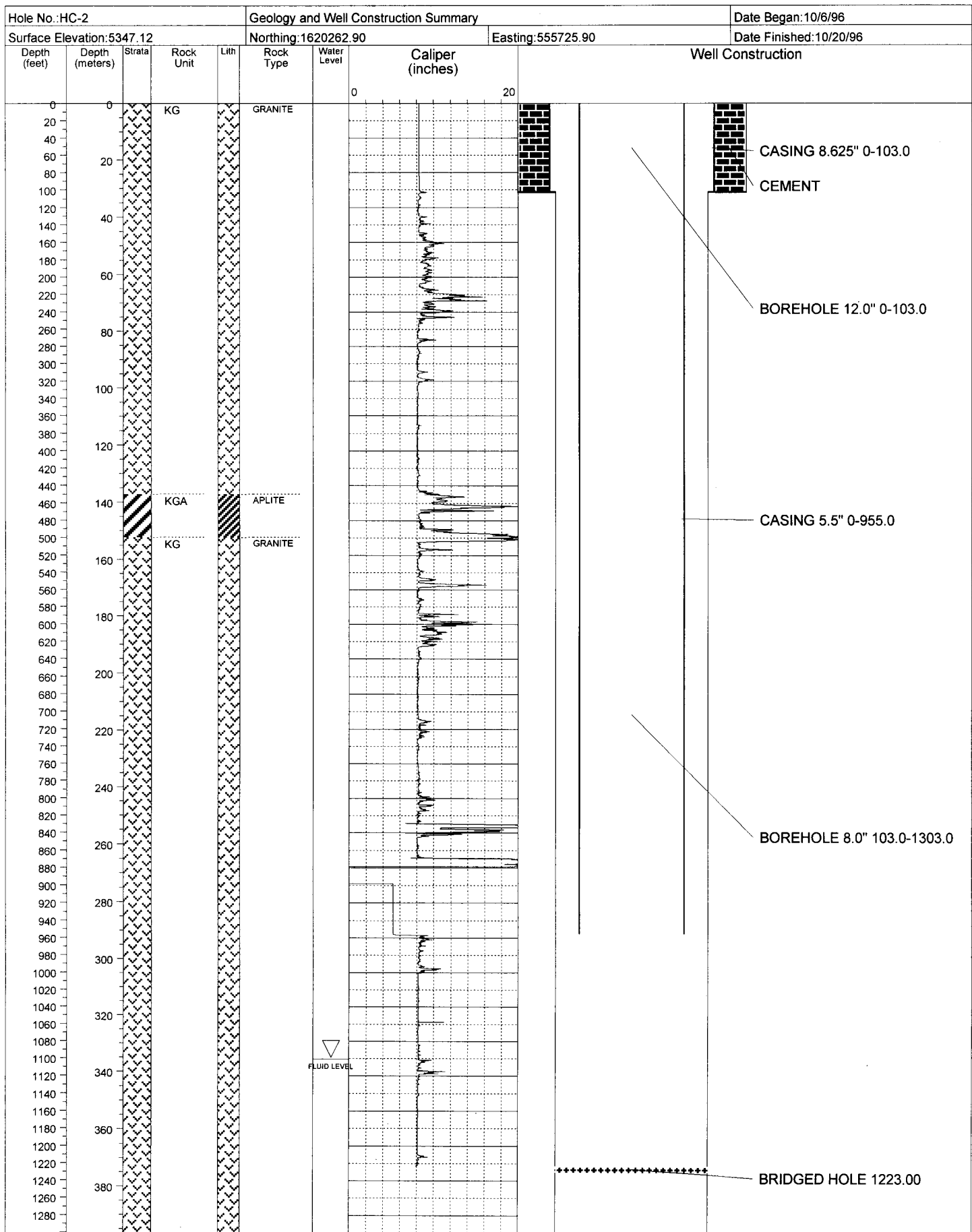
IT CORPORATION  
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 Project No. 764044.03.07.00.00



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 5-8**  
**HC-2 Tritium Concentrations During Drilling**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00



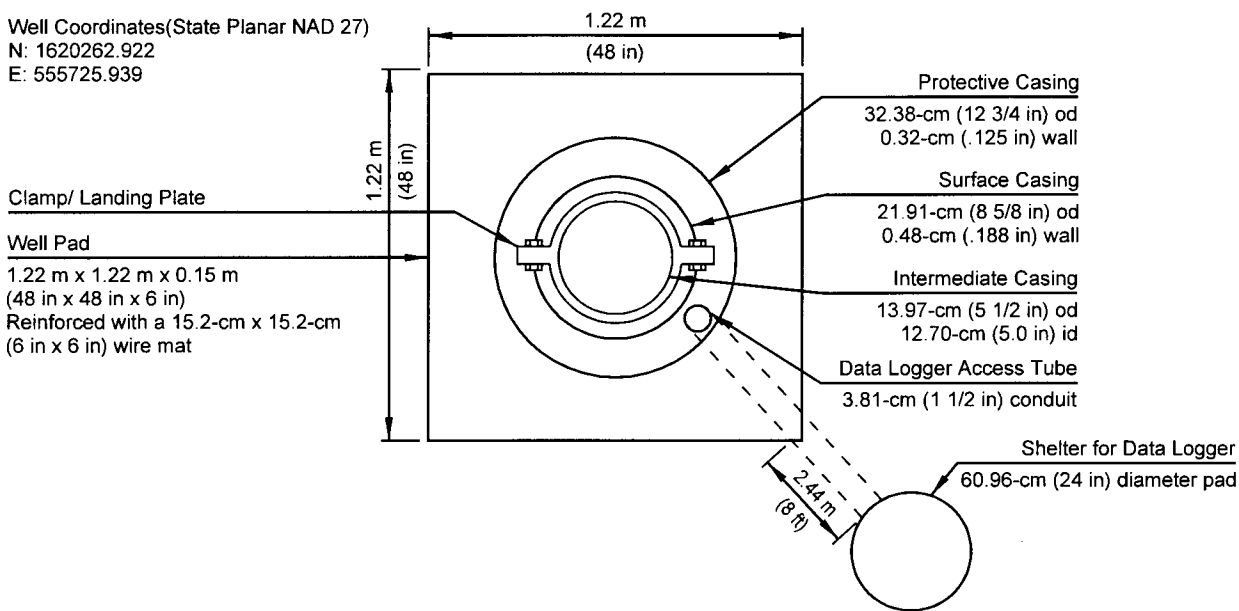
Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 5-9**  
**HC-2 Subsurface Well Completion Diagram**

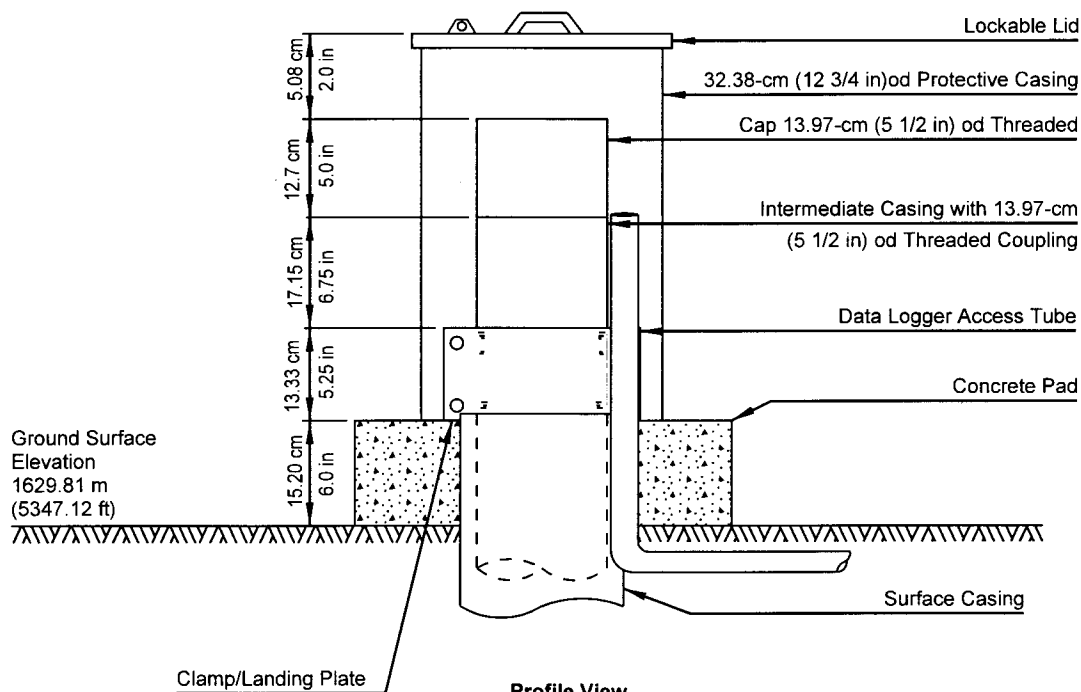
IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00



Well Coordinates(State Planar NAD 27)  
 N: 1620262.922  
 E: 555725.939



Plan View



Profile View

Figure 5-10  
 HC-2 Well Head Completion Diagram

**Table 5-1**  
**HC-2 Lithium Bromide Concentrations**

Date mm/dd/yy	Time (24 hrs)	Depth (ft)	Sample Conc. (mg/L)	Sample Temp (C°)	Sample Source	Analysis By
10/15/96	1530	NA	25.3	20.3	QCCS (20 mg/L)	J. Saavedra
10/15/96	1530	NA	28.1	20.7	Water Truck (WT)	J. Saavedra
10/15/96	1545	1023	0.9	22.4	Discharge Line (DL)	J. Saavedra
10/15/96	1615	NA	33.5	21.9	WT	J. Saavedra
10/15/96	1615	1043	26.9	22.3	DL	J. Saavedra
10/15/96	1645	NA	30.9	23.7	WT	J. Saavedra
10/15/96	1745	NA	18.7	24.4	QCCS (20 mg/L)	J. Saavedra
10/15/96	1745	1063	23.3	23.9	DL	J. Saavedra
10/15/96	1800	NA	32.8	22.4	WT	J. Saavedra
10/15/96	1800	1083	20.6	22.4	DL	J. Saavedra
10/15/96	1900	NA	25.8	23.3	WT	M. Flaughner
10/15/96	1900	1095	26.3	23.5	DL	M. Flaughner
10/15/96	1935	NA	20.9	24.5	QCCS (20 mg/L)	M. Flaughner
10/15/96	2000	NA	26.3	22.7	WT	M. Flaughner
10/15/96	2000	1125	26.0	23.5	DL	M. Flaughner
10/15/96	2100	1150	24.4	24.3	DL	R. Peterson
10/15/96	2100	NA	27.6	21.2	WT	R. Peterson
10/15/96	2100	1150	NA	NA	DL	R. Peterson
10/15/96	2220	NA	20.7	24.6	QCCS (20 mg/L)	R. Peterson
10/15/96	2200	1180	23.8	25.7	WT	R. Peterson
10/15/96	2200	1180	25.2	25.5	DL	R. Peterson
10/15/96	2300	NA	28.6	22.8	WT	R. Peterson
10/15/96	2300	1190	29.1	23.5	DL	R. Peterson
10/15/96	2010	NA	20.9	24.7	QCCS (20 mg/L)	R. Peterson
10/15/96	2330	NA	32.9	24.5	WT	M. Flaughner
10/16/96	0000	NA	25.7	24.7	WT	M. Flaughner
10/16/96	0100	1235	21.2	25.1	DL	M. Flaughner
10/16/96	0155	1240	26.1	22.7	DL	M. Flaughner
10/16/96	0200	NA	21.7	24.2	WT	M. Flaughner
10/16/96	0230	NA	19.6	25.6	QCCS (20 mg/L)	M. Flaughner
10/16/96	0206	NA	24.5	24.4	WT	M. Flaughner
10/16/96	0205	1245	25.2	24.5	DL	M. Flaughner
10/16/96	0300	NA	27.3	21.3	WT	M. Flaughner
10/16/96	0305	1260	25.0	24.1	DL	M. Flaughner
10/16/96	0405	NA	22.6	25.3	WT	M. Flaughner
10/16/96	0405	NA	19.3	25.9	QCCS (20 mg/L)	M. Flaughner
10/16/96	0405	1270	22.2	25.3	DL	M. Flaughner
10/16/96	0505	NA	23.2	25.3	WT	M. Flaughner
10/16/96	0505	1290	24.0	24.9	DL	M. Flaughner
10/16/96	0610	NA	23.9	24.6	WT	M. Flaughner
10/16/96	0610	1300	27.5	24.5	DL	M. Flaughner
10/16/96	0615	NA	22.8	25.2	QCCS (20 mg/L)	M. Flaughner
10/16/96	0622	NA	29.3	23.6	WT	M. Flaughner
10/16/96	0622	1300	28.5	23.9	DL	M. Flaughner
10/16/96	0637	NA	27.6	24.5	WT	J. Saavedra
10/16/96	0637	1300	28.5	24.7	DL	J. Saavedra
10/16/96	0652	NA	30.5	23.1	WT	J. Saavedra
10/16/96	0744	NA	22.4	24.2	QCCS (20 mg/L)	J. Saavedra
10/16/96	0652	1300	28.9	25.0	DL	J. Saavedra
10/16/96	0800	NA	27.9	25.6	WT	J. Saavedra
10/16/96	0800	1300	25.2	25.5	DL	J. Saavedra
10/16/96	0945	NA	29.8	23.4	WT	J. Saavedra
10/16/96	1105	1300	34.6	23.8	DL	J. Saavedra

**Table 5-2**  
**HC-2 Water Level Measurements**

Well Name	Date	Depth to Fluid (ft)	Elevation (ft)	Notes
HC-2	19-Oct-96	1135.25	4211.87	DRI video log initial water level after drilling.
HC-2	19-Oct-96	1129.03	4218.09	IT water monitoring using solinist tape. Meas. to top of casing, approx 3.2 ft above GL
HC-2	19-Oct-96	1130.31	4216.81	IT water monitoring using solinist tape. Meas. to top of casing, approx 3.2 ft above GL
HC-2	19-Oct-96	1127.85	4219.27	IT water monitoring using solinist tape. Meas. to top of casing, approx 3.2 ft above GL
HC-2	20-Oct-96	1110	4237.12	Fluid level from Century neutron logs. Water level estimated from GL.
HC-2	21-Oct-96	1108.8	4238.32	DRI transducer water level to ground surface.
HC-2	21-Oct-96	1108.29	4238.83	IT water monitoring using solinist tape. Measurement to ground surface.
HC-2	21-Oct-96	1108.52	4238.6	Water level obtained by IT Corp. using solinst. Measurement to ground surface.
HC-2	22-Oct-96	1107.12	4240	DRI water level via in hole transducer. Datum is ground surface.
HC-2	23-Oct-96	1105.82	4241.3	DRI transducer water level. Level determined to ground level.
HC-2	07-Nov-96	1102.9	4244.22	Water level obtained by DRI after removing the transducer using an EC temp. tool at GL.
HC-2	13-Nov-96	1101	4246.12	Approx. water level obtained from the DRI down hole video camera. Measurement to GL.

**Table 5-3**  
**HC-2 List of Geophysical Logs**

<b>Well Name</b>	<b>Geophysical Log</b>	<b>Date Logged</b>	<b>Log Top (ft)</b>	<b>Log Bottom (ft)</b>	<b>Logging Company</b>
HC-2	3-Arm Caliper	10/18/96	0.00	878.60	Century Geophysical
HC-2	3-Arm Caliper	10/19/96	897.70	1223.00	Century Geophysical
HC-2	Density/Resistivity/Neutron/Neutron Porosity	10/18/96	0.00	880.50	Century Geophysical
HC-2	Density/Resistivity/Neutron/Neutron Porosity	10/19/96	881.80	1224.00	Century Geophysical
HC-2	Deviation - magnetic	10/16/96	0.00	876.00	Century Geophysical
HC-2	Deviation - gyroscopic	10/19/96	0.00	1214.30	Century Geophysical
HC-2	Spectra Gamma Ray (K, U, Th)	10/18/96	0.00	879.50	Century Geophysical
HC-2	Spectra Gamma Ray (K, U, Th)	10/19/96	901.50	1223.30	Century Geophysical
HC-2	Temperature	10/19/96	892.10	1225.80	Century Geophysical
HC-2	Acoustic Borehole Televier	10/20/96	1110.86	1222.82	Century Geophysical
HC-2	Acoustic Borehole Televier	10/20/96	1110.64	1222.58	Century Geophysical
HC-2	Chemtool	9/21/96	1110.00	1224.00	DRI
HC-2	Chemtool	11/14/96	1106.00	1225.00	DRI
HC-2	Downhole Video Camera	10/18/96	882.00	0.00	DRI

Note: Calibrations and repeat sections were performed per contract specifications.

**Table 5-4**  
**HC-2 Summary of Subsurface Investigation Samples**

Sample Number	Date Collected	Location	Sample Type	Depth (ft)	COC Number	Comments
PSC00001	10/2/96	HC-1	Cuttings	930	519811	Cuttings sample collected at HC-1 during drilling.
PSW00003	10/4/96	HC-1	Groundwater	920	519812	Groundwater sample from HC-1 Well Development...Full Lab QC
PSW00004	10/4/96	HC-1	Groundwater (dup)	920	519812	Duplicate of sample PSW00003
PSW00005	10/4/96	HC-1	Water (QC)	NA	519812	Equipment Rinsate sample
PSW00006	10/4/96	HC-1	Water (QC)	NA	519812	Field Blank sample
PSF00001	10/5/96	HC-1	Discharge Fluid	NA	519816	Composite sample collected at HC-1 Sump #1
PCX00001	11/3/96	HC-1	2nd Discharge Fluid	NA	519820	Additional fluids discharged into HC-1 Sump #1, 2nd composite sample collected.
PSC00002	10/16/96	HC-2	Cuttings	1253	519813	Cuttings sample from HC-2 taken during drilling.
PSW00007	10/21/96	HC-2	Groundwater	1173	519814	Groundwater sample from HC-2 Well Development.
PSF00003	10/20/96	HC-2	Discharge Fluid	NA	522037	Composite sample collected at HC-2 Sump #1.
PSC00003	11/5/96	HC-3	Cuttings	1255	519822	Cuttings sample from HC-3 taken during drilling.
PSW00008	11/14/96	HC-3	Groundwater	1104	519823	Groundwater sample from HC-3 Well Develop. Waiting on results.
PSF00005	11/12/96	HC-3	Discharge Fluid	NA	519824	Composite sample collected at HC-3, Sump #1.
PSC00004	10/23/96	HC-4	Cuttings	1250	519817	Cuttings sample collected at HC-4 during drilling.
PSW00009	11/7/96	HC-4	Groundwater	1130	519819	Groundwater sample from HC-4 using a discrete bailer.
PSF00007	10/24/96	HC-4	Discharge Fluid	NA	519818	Composite sample collected at HC-4, Sump #1

**Table 5-5a to 5-5f**  
**HC-2 Sample Results**  
 (Page 1 of 3)

**Table 5-5a**

Sample Location	Sample #	Sample Date	Matrix	Aluminum (mg/L) <sup>a</sup>	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)
HC-2	PSC00002	10/16/96	Cuttings	N/A <sup>b</sup>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSW00007	10/21/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSF00003	10/20/96	Sump	N/A	N/A	0.0621	0.0556	N/A	N/A	0.003 (ND) <sup>c</sup>	N/A	0.0044 (ND)

**Table 5-5b**

Sample Location	Sample #	Sample Date	Matrix	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Lithium (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
HC-2	PSC00002	10/16/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSW00007	10/21/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSF00003	10/20/96	Sump	N/A	N/A	N/A	0.0074	N/A	N/A	N/A	0.00025	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 5-5a to 5-5f**  
**HC-2 Sample Results**  
 (Page 2 of 3)

**Table 5-5c**

Sample Location	Sample #	Sample Date	Matrix	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Strontium (mg/L)	Thallium (mg/L)
HC-2	PSC00002	10/16/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSW00007	10/21/96	Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-2	PSF00003	10/20/96	Sump	N/A	N/A	0.0031	N/A	0.0066 (ND)	N/A	N/A	N/A

**Table 5-5d**

Sample Location	Sample #	Sample Date	Matrix	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	Tritium (pCi/L) <sup>d</sup>	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Bismuth-214 (pCi/L)
HC-2	PSC00002	10/16/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	0.82 pCi/g <sup>e</sup>
HC-2	PSW00007	10/21/96	Groundwater	N/A	N/A	N/A	2	70.1	64.6	36.9
HC-2	PSF00003	10/20/96	Sump	N/A	N/A	N/A	13	6.15	6.61	ND <sup>f</sup>

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 5-5a to 5-5f**  
**HC-2 Sample Results**  
 (Page 3 of 3)

**Table 5-5e**

Sample Location	Sample #	Sample Date	Matrix	Cesium-137 (pCi/L)	Lead-212 (pCi/L)	Lead-214 (pCi/L)	Potassium-40 (pCi/L)
HC-2	PSC00002	10/16/96	Cuttings	0.17 pCi/L (ND)	ND pCi/g	ND pCi/g	27.8 pCi/g
HC-2	PSW00007	10/21/96	Groundwater	4.5 (ND)	44.6	41.2	1210
HC-2	PSF00003	10/20/96	Sump	ND	ND	ND	ND

**Table 5-5f**

Sample Location	Sample #	Sample Date	Matrix	Radium-226 pCi/L	Radium-228 pCi/L	Thallium-208 (pCi/L)
HC-2	PSC00002	10/16/96	Cuttings	ND pCi/g	ND pCi/g	0.22 pCi/g
HC-2	PSW00007	10/21/96	Groundwater	100	55.6	ND
HC-2	PSF00003	10/20/96	Sump	ND	ND	ND

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

## **6.0 Well HC-3 Summary of Operations**

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Well HC-3 was drilled to a depth of 397.15 m (1,303.0 ft), between November 3, 1996, and November 10, 1996. Eight days were spent drilling and completing the installation of this well. Note that the [Figures 6-1 through 6-9 and Tables 6-1 through 6-5](#), cited in the following text, are located at the end of this section.

Prior to mobilization, all drilling equipment was decontaminated at the on-site decontamination pad using a combination of steam cleaning and high pressure washing. Decontaminated equipment was subjected to radiologic screening prior to mobilization to the drill site.

A 30.48-cm (12.0-in.) hole for the surface conductor was drilled using reverse air rotary reverse circulation techniques and a downhole percussion hammer to a depth of 31.39 m (103.0 ft) bgs. A 21.91-cm (8.625-in.) carbon steel casing was installed in this hole and cemented to the surface using Type II cement with 2 percent calcium chloride additive.

The main hole was drilled from below the casing point to a TD of 397.15 m (1,303.0 ft) bgs using a 20.32-cm (8.0-in.) downhole percussion hammer and air rotary reverse circulation techniques. Drilling progressed smoothly during the advance of the main hole. Some short delays resulted from leaks/washouts of the discharge hose and cyclone; repairs were made quickly; and drilling resumed. Drilling parameters for the well are provided in [Figure 6-1](#). All figures and tables cited in the text are located at the end of this section.

Upon completion of drilling operations, the well was circulated and developed for a period of several hours. No fill was noted after completion of these operations, and the drill pipe was tripped out of the hole on November 11, 1996, in anticipation of geophysical logging.

Geophysical logging commenced early on November 11, 1996. The first log run by DRI encountered a bridge/obstruction at a depth at 165.81 m (544.0 ft) bgs. DRI removed the wireline from the hole, and the bridge was removed with a sinker bar. DRI reentered the borehole and resumed logging. A second borehole obstruction was encountered at a depth of 362.71 m (1,190.0 ft) bgs. Several unsuccessful attempts were made to remove the obstruction using a sinker bar. Beylik tripped back into the hole with a 20.0-cm (7.875-in.) percussion hammer bit to clear the obstruction. Circulation was established at 304.8 m (1,000 ft) bgs. Severe sloughing of the borehole was experienced in the interval between 329.18 and 335.28 m (1,080.0 and

1,100.0 ft) bgs, resulting in poor circulation and plugging of the drill bit. The drilling assembly was tripped from the hole on November 11, 1996, and converted to conventional/direct circulation. In order to facilitate conventional circulation, a second air compressor was placed on site. Initial, direct circulation was established at a depth of 1,080 ft (329.81 m) using a mixture of fresh water and foam. The well was then circulated and cleaned to TD of 397.15 m (1,303.0 ft) bgs. Upon cleaning/circulating the borehole for a short period, the drill pipe was pulled back to a depth of 365.75 m (1,200.0 ft) bgs to check for sloughing in the well.

The drilling assembly was lowered into the well to the TD of 397.15 m (1,303 ft) bgs, and attempts to regain circulation were made without success. The drilling assembly was then tripped out to a depth of 377.95 m (1,240.0 ft) bgs to make additional attempts to regain circulation. After several attempts using foam and fresh water met with limited success, the drilling subcontractor ran out of foam additive for the drilling fluids. Continued efforts to circulate using only fresh water proved unsuccessful. Sloughing hole conditions resulted in the additional loss of hole to a depth of 370.33 m (1,215 ft) bgs. It was determined that the drilling assembly be pulled from the hole and intermediate casing be set to isolate sloughing portions of the hole.

On November 8, 1996, prior to setting intermediate casing, Century Geophysical completed a suite of geophysical logs within the unsaturated portions of the borehole to a depth of 311.81 m (1,023.0 ft) where a bridge prevented further logging.

Intermediate 13.97-cm (5.5-in.) carbon steel casing was set to a depth of 333.57 m (1,094.4 ft) bgs after completing the unsaturated logging suite. Water level at the time the casing was set was recorded at a depth of 330.10 m (1,083.0 ft). Upon setting of intermediate casing, a sinker bar was run on the sand line to determine the TD of the well. The resulting measurement indicated the well was bridged at a depth of 338.33 m (1,110.0 ft) bgs.

The hole was reentered on November 8, 1996, with a 11.75-cm (4.625-in.) tricone button bit using a reverse circulation drilling assembly to attempt to clean out the well to TD. Several attempts to clean and circulate to depths below the casing resulted in further sloughing of the borehole and several plugged drill strings and bits. Clean out operations were conducted to a depth of 384.05 m (1,260.0 ft) bgs, at which time it was determined to accept the depth of the well as the TD. The drill pipe was pulled from the well, and Century Geophysical attempted to log to the TD of the well when they encountered a bridge at a depth of 347.78 m (1,141.0 ft) bgs. This depth was considered too shallow to allow access to saturated portions of the borehole. Several attempts were made to clear the bridge using a sinker bar on a sand line with no

appreciable progress. The hole was again reentered with a 11.75-cm (4.625-in.) tricone bit using reverse circulation. Several attempts were made to clean out the borehole, resulting in several episodes of plugging of the drill bit and drill pipe. On the morning of November 10, 1996, efforts to clean the borehole were abandoned, and the drill pipe was pulled from the borehole in preparation for geophysical logging. The TD of the well recorded by Century Geophysical was 345.98 m (1,135.1 ft) bgs. The water level noted during logging at this time was 337.11 m (1,106.0 ft) bgs.

### **6.1 Well HC-3 Geology**

Well HC-3 principally encountered a fractured, coarse-grained, biotite granite of Cretaceous age throughout the drilled interval. Significant fault/fracture zones were apparent over the following intervals: 161.54 to 170.69 m, 274.32 to 283.46 m, 292.61 to 297.18 m, and 338.33 to 353.57 m (530.0 to 560.0 ft, 900.0 to 930.0 ft, 960.0 to 975.0 ft, and 1,110.0 to 1,160.0 ft). No andesite was noted in the original cuttings collection process; however, andesitic cuttings were noted in the drilling returns from attempts to clean fill and obstructions from the well. The occurrence of these cuttings suggest that thin andesite dikes or dikelets may occur within some of the fault or fracture zones. A descriptive lithologic log is provided as [Figure 6-2](#).

### **6.2 Well HC-3 Hydrology**

Several elements of hydrologic importance were monitored during and after the completion of the well. During drilling operations, the following two monitoring parameters were consistently compared: the volume of drilling fluids (water/foam) injected to facilitate drilling and volumes of fluid produced as discharge to the surface during the same time. [Figure 6-3](#) illustrates the relationships between injected drilling fluids and drilling fluid produced at the surface.

In addition to these volumetric measurements, all drilling fluids injected into the borehole were tagged with a tracer solution of LiBr. The concentration of this solution was monitored on a regular basis to estimate groundwater production within the borehole. [Figure 6-1](#) illustrates LiBr concentrations noted in produced fluids.

Water production from the well was minimal; monitoring data and water level recovery data suggest the well was capable of producing approximately 2.8 to 3.8 L/min (0.75 to 1.0 gpm). During several instances, the well was capable of intermittent production on the order of 11.4 to 18.9 L/min (3.0 to 5.0 gpm). These readings suggest production from perched water zones along fault or fracture zones. These zones were of limited impact as their storage capacities were exhausted and their contribution to well bore decreased.

Water-level monitoring was conducted during the construction of the well and continued after completion using transducers set by DRI. [Table 6-2](#) provides water levels obtained for the term of IT involvement in PSA field work.

### **6.3 Well HC-3 Geophysical Surveys**

Upon completion of drilling to the TD of 397.15 m (1,303.0 ft) and after a session of well development, a suite of downhole geophysical surveys was run within the borehole. Due to unstable borehole conditions geophysical logging was conducted in two phases. The first phase consisted of logging by Century Geophysical and DRI to a depth of approximately 311.81 m (1,023.0 ft) bgs. Upon completion of these logging runs, intermediate casing was installed in the well to a depth of 333.57 m (1,094.40 ft) bgs. After casing installation, the well was logged from below the casing point to the accessible TD of the well of 345.98 m (1,135.1 ft) bgs. That portion of the borehole from 311.81 to 333.57 m (1,023.0 to 1,094.4 ft) bgs was not available for geophysical logging due to unstable borehole conditions and the resulting installation of intermediate casing.

Geophysical logs specified for the saturated portion of the borehole were not conducted due to the slow recovery of water levels in the well and the short interval of open borehole below the casing point.

Deviation surveys conducted within the casing and borehole indicate the borehole was deviated 18.1 degrees from vertical in a west-southwest direction. The deviation of the hole placed the bottom of the hole 40.08 m (131.5 ft) west-southwest of the collar and resulted in a true vertical depth of 304.89 m (1,000.30 ft) bgs.

[Table 6-3](#) provides a summary of the geophysical logs run for the well and the corresponding logged intervals. Additional specialized logging was performed by DRI as part of their scientific work scope. [Figures 6-4 to 6-6](#) provide condensed illustrations of log traces for Well HC-3.

### **6.4 Well HC-3 Radiologic Monitoring**

Monitoring of discharge effluent from drilling was conducted as specified in the Project Shoal SSHASP (DOE/NV, 1996b) and the FMP for the Project Shoal Area Offsite Subproject (DOE/NV, 1996c). Regular radiological monitoring of discharged drilling effluents, including both fluids and solids, was conducted by Bechtel Nevada radiation control technicians.

Samples for further on-site lab analysis were screened using handheld instruments at the time of sample collection. Effluents were then analyzed for tritium and other radionuclides using on-site laboratory monitoring equipment. Tritium activities from fluid and swiped samples were recorded using a Packard Liquid Scintillation instrument. Other radionuclides were analyzed using Canberra gamma spectroscopy instrumentation.

Well HC-3 drilling effluents were found to contain only natural background levels of tritium and other radionuclides based on results of field monitoring. [Figure 6-7](#) provides a profile of tritium encountered from fluids generated during drilling.

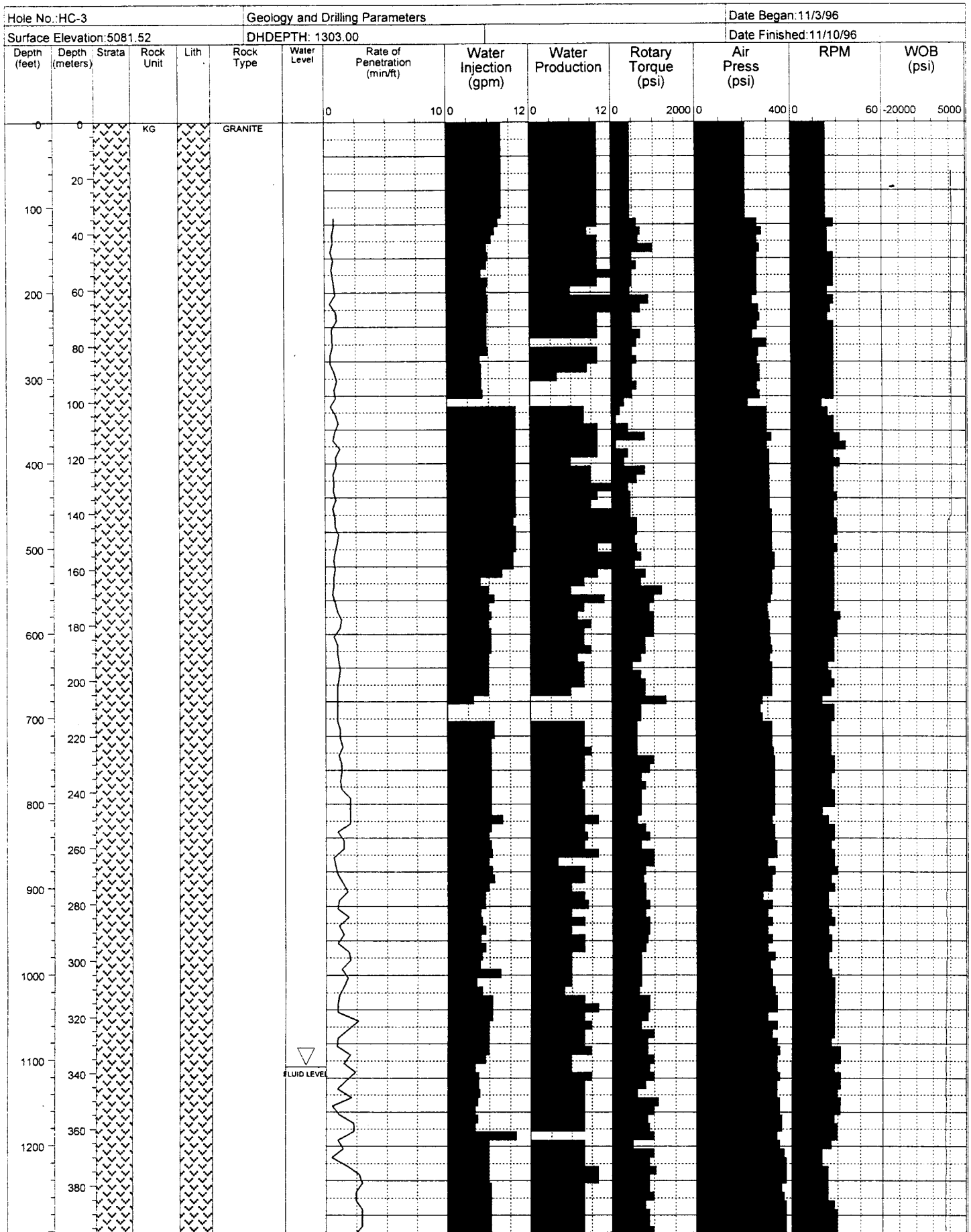
### **6.5 Well HC-3 Well Construction**

Construction of Well HC-3 included the drilling of a 30.48-cm (12.0-in.) surface borehole to a depth of 31.39 m (103.0 ft). Conductor casing comprised of 21.91-cm (8.625-in.) carbon steel was installed in the 30.48-cm (12-in.) hole. Bow-type centralizers were placed approximately 1.52 m (5.0 ft) from the bottom of the casing and then centered at the surface. Conductor casing was cemented to the surface using Type II neat cement with 2 percent calcium chloride as an additive to aid curing time. A 20.32-cm (8.0-in.) borehole was drilled to a TD of 397.15 m (1,303.0 ft) bgs from beneath the conductor casing.

Intermediate 13.97-cm (5.50-in.) carbon steel casing was installed in the completed borehole and set at a depth of 333.57 m (1,094.4 ft) bgs. Intermediate casing was installed without specified centralizers or cement baskets due to adverse borehole conditions. Intermediate casing was suspended on landing straps secured to the surface conductor casing. [Figure 6-8](#) provides a schematic view of the final completion, and the surface completion for the well head is illustrated in [Figure 6-9](#).

## **6.6 Well HC-3 Sampling**

Samples for analytical analysis were collected from fluids and cuttings as specified in the *Field Instructions for Project Shoal Area Surface and Subsurface Investigation, Churchill County, Nevada* (IT, 1996) and the FMP for the Project Shoal Area Offsites Subproject (DOE/NV, 1996c). The sample type and analytical results of these samples are shown in [Tables 6-4 and 6-5](#).



Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

**Figure 6-1**  
**Summary of Well HC-3 Drilling Parameters**

IT CORPORATION

Project Shoal

Project No. 764044.03.07.00.00

Well ID. HC-3 GRANITE 0.00 200.00 jaw 11/04/96  
Granite, light grayish white to light pinkish gray, porphyritic, milky white to pinkish white kspar, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 3 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings are prevalent through out most cuttings. Cuttings quality is good with chips nominally 2-4mm, larger cuttings noted in the interval 110-120 indicating a possible fracture.

Well ID. HC-3 GRANITE 200.00 300.00 jaw 11/04/96  
Granite, light grayish white to light pinkish gray, porphyritic, milky white to pinkish white kspar, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 3 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings are prevalent through out most cuttings. Cuttings quality is good with chips nominally 2-4mm, larger cuttings noted in the interval 210-220, 230-240 and 280-290 with cuttings to 10 -15 mm indicating a possible fractures. Schlieren foliation noted in the interval 200-210' along with chloritization of rock.

Well ID. HC-3 GRANITE 300.00 400.00 jaw 11/04/96  
Granite, light grayish white to light gray, porphyritic, milky white to slightly pinkish white kspar, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 3 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings are prevalent through out most cuttings. Cuttings quality is good with chips nominally 2-4mm.

Well ID. HC-3 GRANITE 400.00 600.00 jaw 11/04/96  
Granite, light grayish white to light gray, porphyritic, milky white to slightly pinkish white kspar, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 3 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings are prevalent through out most cuttings. Cuttings quality is good with chips nominally 2-4mm. Apparent fracture zone 410-450' large blocky cuttings/rubble to 20mm. Other minor fractures? noted 530-540' and possibly 590-600'.

Well ID. HC-3 GRANITE 600.00 800.00 jaw 11/05/96  
Granite, light grayish white to light gray, porphyritic, milky white to slightly pinkish white kspar, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 10 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings are prevalent through out most cuttings. Cuttings quality is good with chips nominally 2-4mm. Large cuttings indicative of potential

Figure 6-2  
Well HC-3 Lithologic Descriptions  
(Page 1 of 2)

fractures or zones of fractures noted in the interval 630-640', 690-700' and 720-750' cuttings in these intervals range from 10 -15mm.

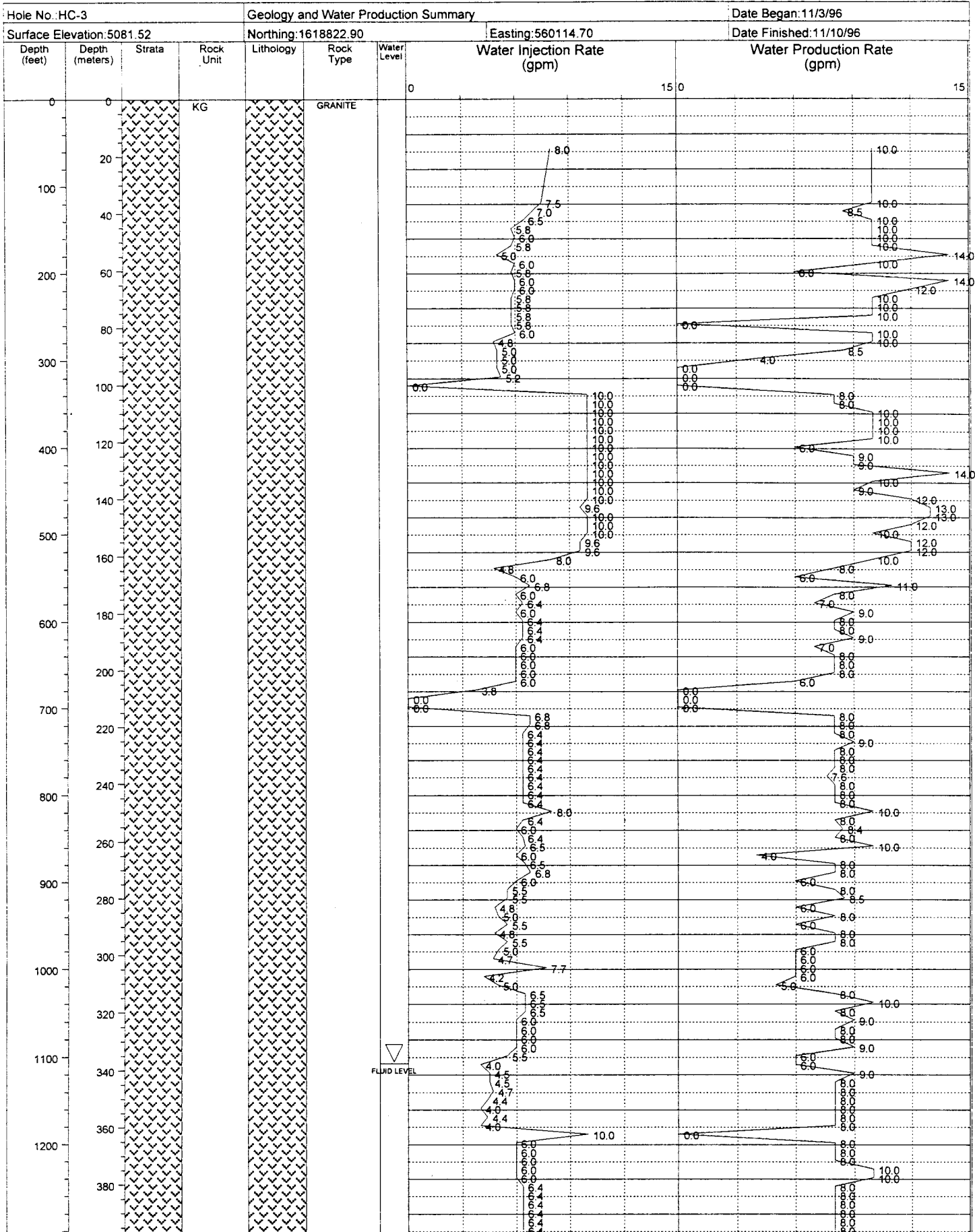
Well ID. HC-3                      GRANITE                      800.00    880.00    jaw 11/05/96  
Granite, light grayish white to light gray, porphyritic, milky white to slightly pinkish white ksp, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 10 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings mostly on quartz xls are prevalent through out most cuttings. Interval is mostly fractured with large (10-20mm) rubbly cuttings noted throughout the interval.

Well ID. HC-3                      GRANITE                      880.00    1060.00    jaw 11/05/96  
Granite, light grayish white to light gray, porphyritic, milky white to slightly pinkish white ksp, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 10 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings mostly on quartz xls are prevalent through out most cuttings. Cuttings quality is generally good with cuttings ranging from 1-3mm. Interval 920-930' and 970-980' contain larger cuttings 5-12mm suggesting possible fracture zone.

Well ID. HC-3                      GRANITE                      1060.00    1150.00    jaw 11/05/96  
Granite, light grayish white to pinkish light gray, porphyritic, milky white to slightly pinkish white ksp, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 10 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings mostly on quartz xls are prevalent through out most cuttings. Cuttings quality is generally good much of the interval is comprised of large rubbly cuttings (5-20mm) likely resulting from a fracture zone.

Well ID. HC-3                      GRANITE                      1150.00    1303.00    jaw 11/06/96  
Granite, light grayish white to pinkish light gray, porphyritic, milky white to slightly pinkish white ksp, principally microcline up to 15mm occur as prominent porphyritic subhed to euhed xls and in total comprise (35-40%) of the whole rock. Groundmass comprised of medium to coarse grained clear to milky quartz xls (30%), minor white to translucent plagioclase (<10%). Black to greenish black biotite is abundant consisting of isolated thin booklets and individual xls altering locally to chlorite, some smaller aggregates to 10 mm (10%), Magnetite also noted as isolated blebs and subhed xls < 2mm. Spotty faint yellow to ocherous orange limonite/hematite stains and coatings mostly on quartz xls are prevalent through out most cuttings. Cuttings quality is generally good with a nominal size of 2.0-3.0 mm. Possible fracture zone exists in the interval 1230 - 1240 as cuttings are 8-12 mm.

**Figure 6-2**  
**Well HC-3 Lithologic Descriptions**  
(Page 2 of 2)



Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

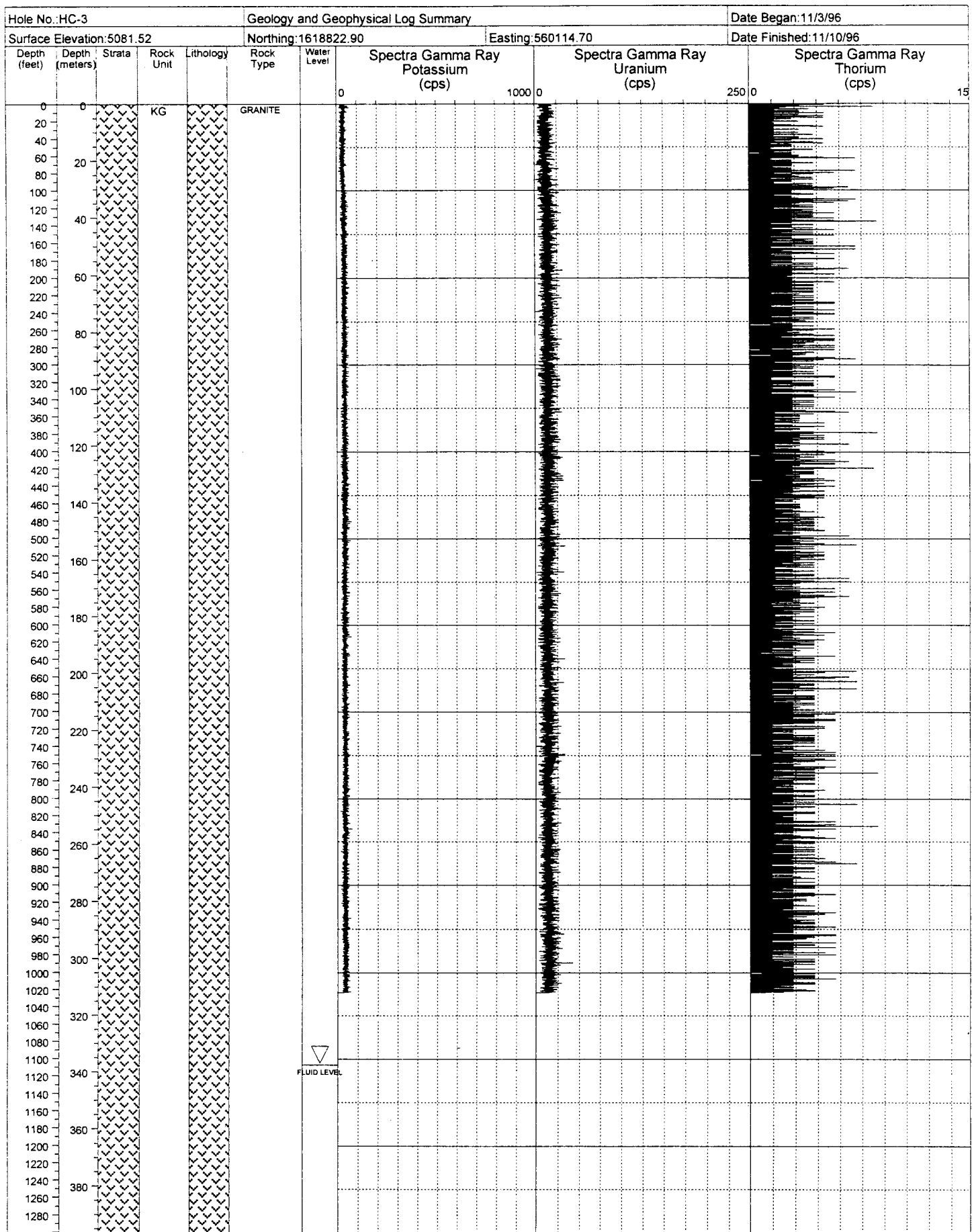
Figure 6-3

HC-3 Fluid Injection versus Production Diagram

IT CORPORATION

Project Shoal

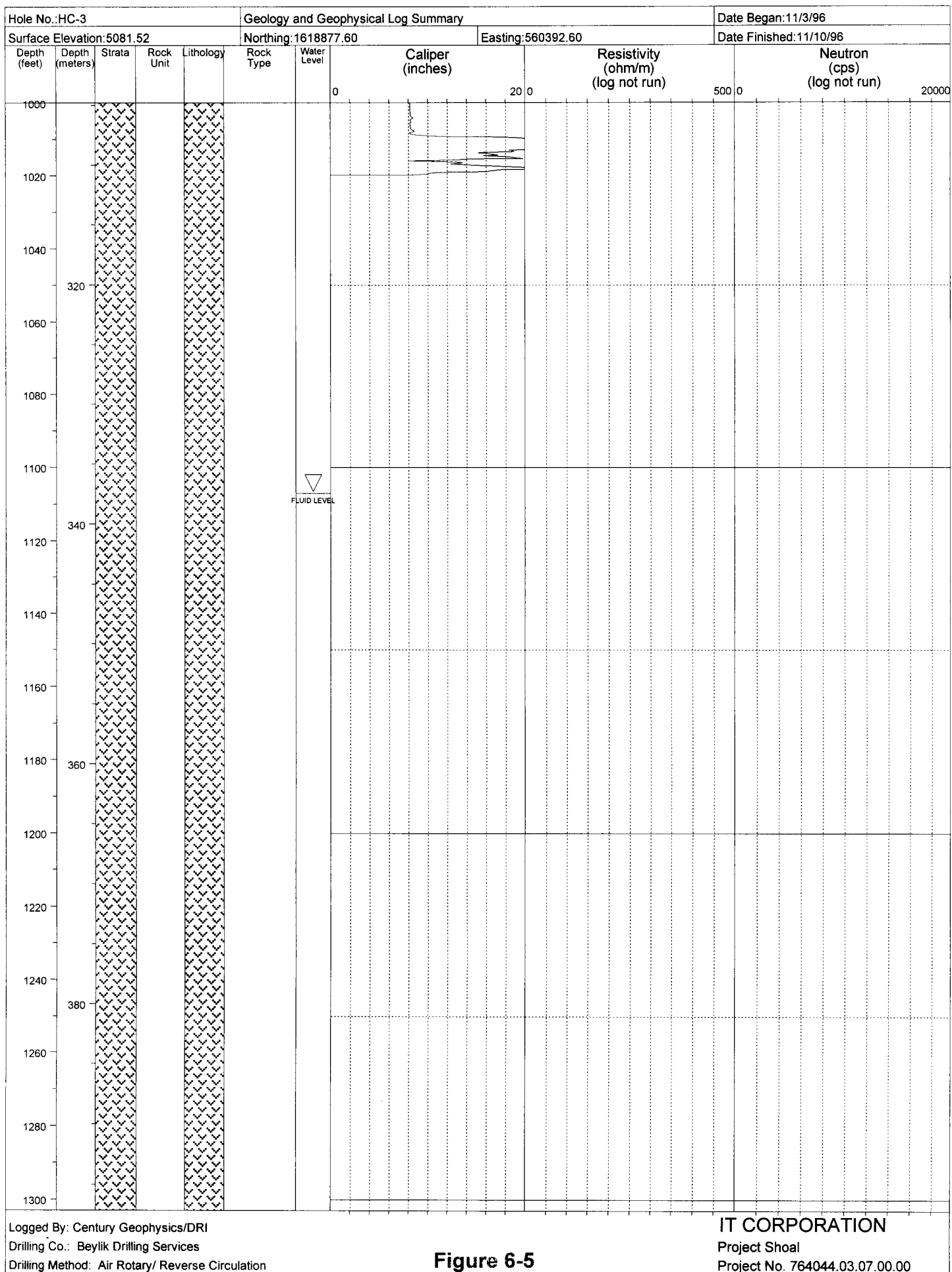
Project No. 764044.03.07.00.00

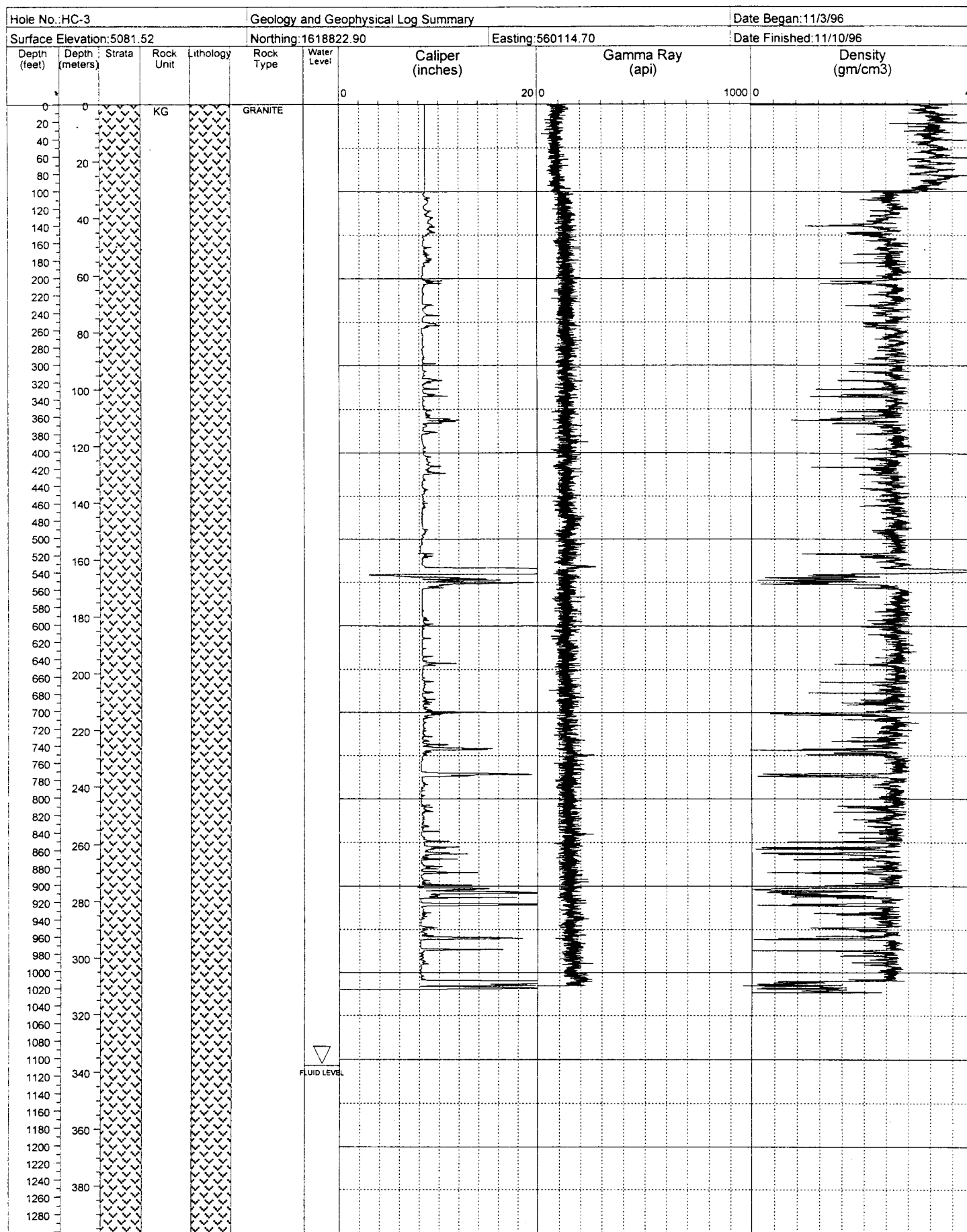


Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

**Figure 6-4**  
**HC-3 Geophysical Log Traces of Spectra Gamma Ray**

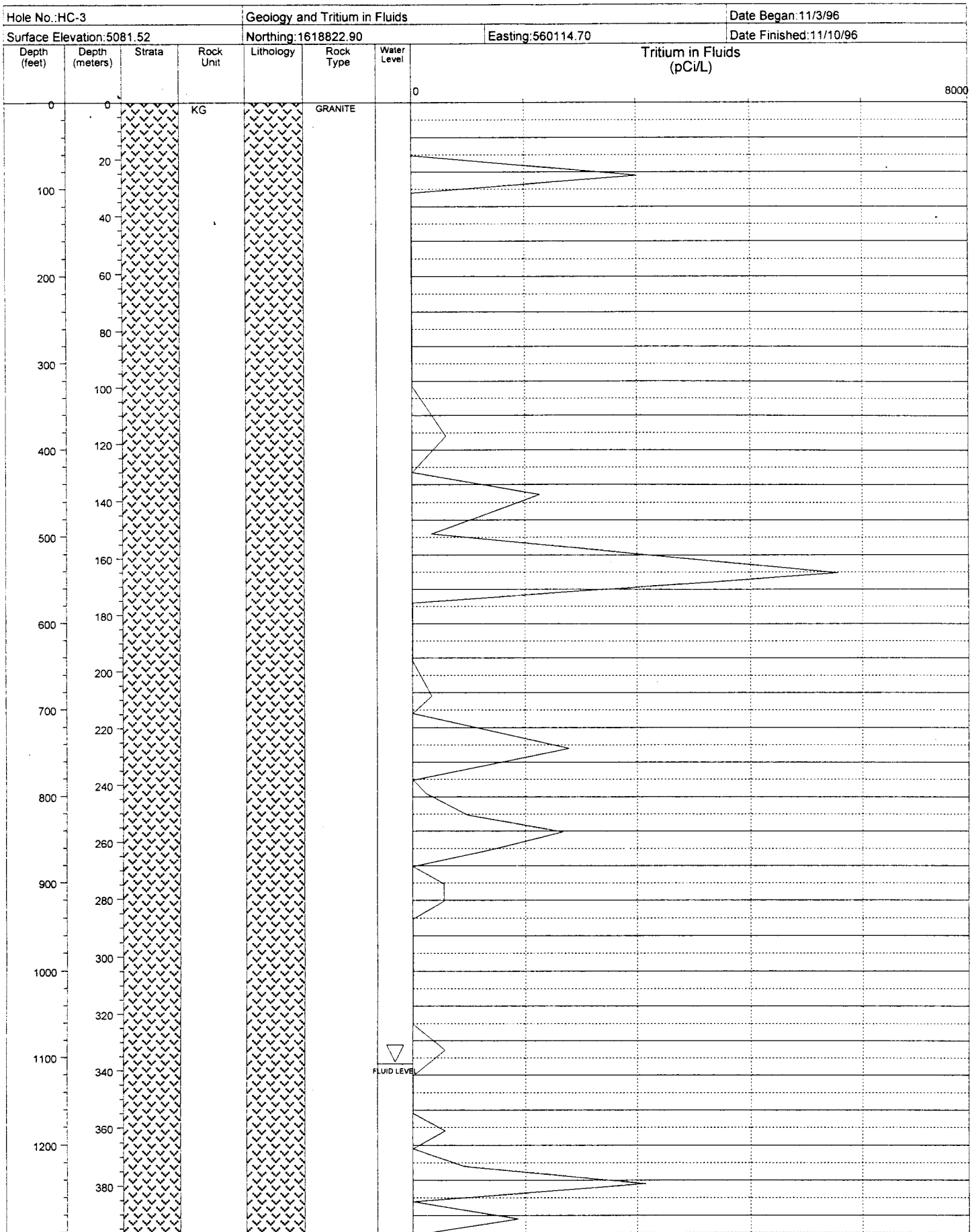




Logged By: Century Geophysics/DRI  
Drilling Co.: Beylik Drilling Services  
Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
Project Shoal  
Project No. 764044.03.07.00.00

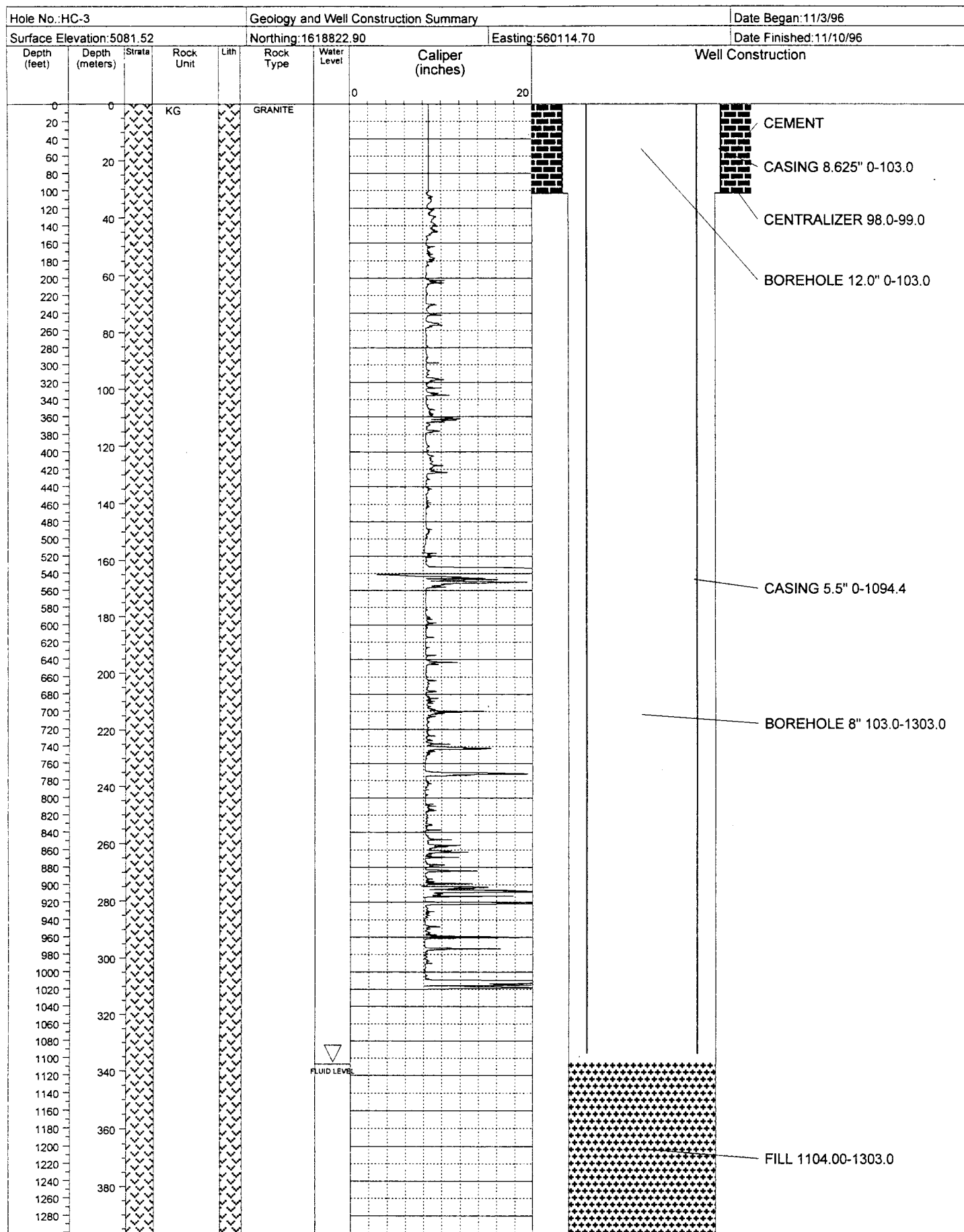
**Figure 6-6**  
**HC-3 Geophysical Log Traces of Caliper, Gamma Ray, Density**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 6-7**  
**HC-3 Tritium Concentrations During Drilling**

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 Project Shoal  
 Project No. 764044.03.07.00.00



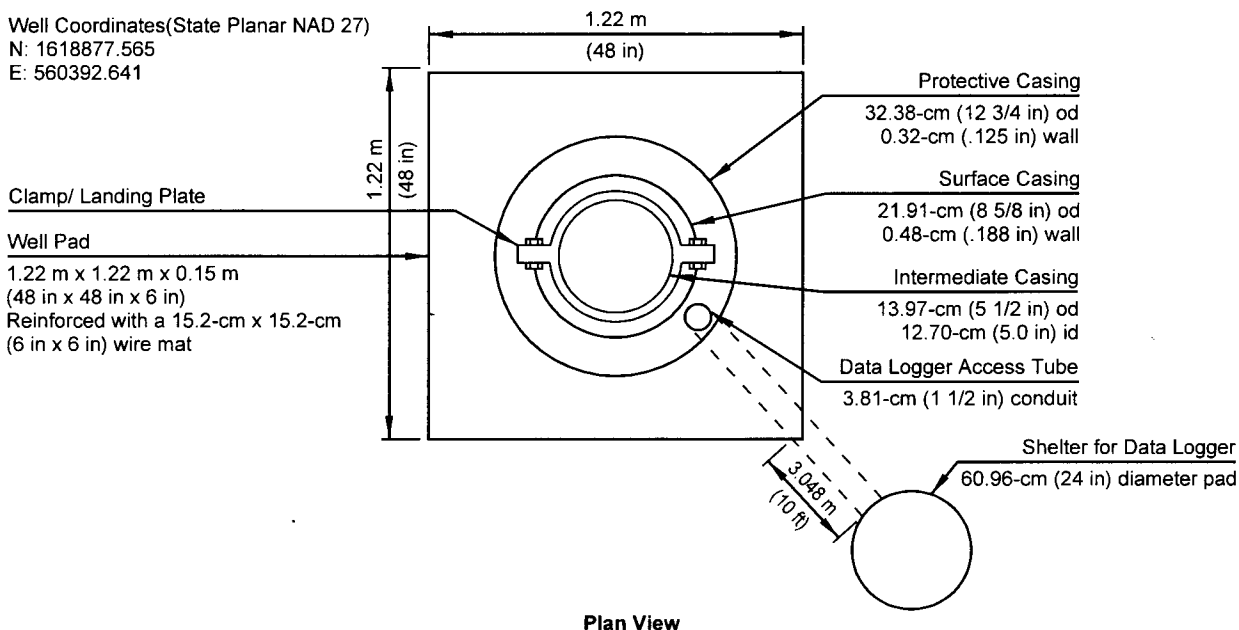
Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 6-8**  
**HC-3 Subsurface Well Completion Diagram**

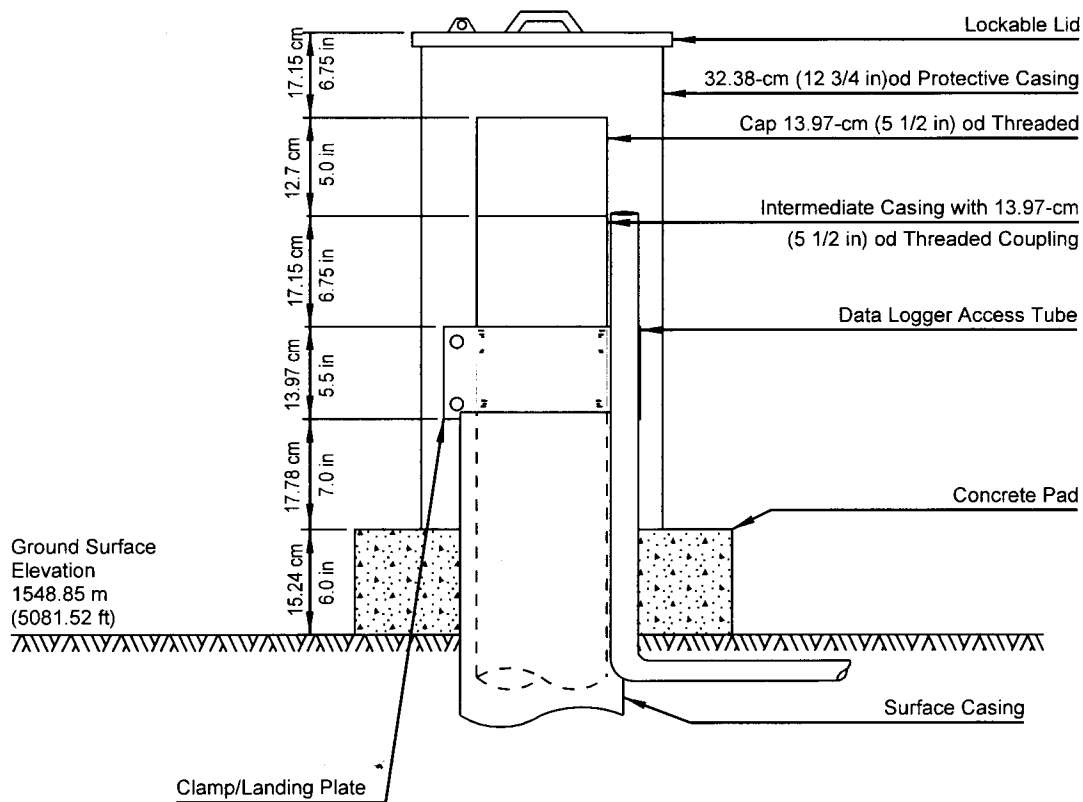
IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00



Well Coordinates(State Planar NAD 27)  
 N: 1618877.565  
 E: 560392.641



Plan View



Profile View

Figure 6-9  
 HC-3 Well Head Completion Diagram

**Table 6-1**  
**HC-3 Lithium Bromide Concentrations**

<b>Date mm/dd/yy</b>	<b>Time (24 hrs)</b>	<b>Depth (ft)</b>	<b>Sample Conc. (mg/L)</b>	<b>Sample Temp (C°)</b>	<b>Sample Source</b>	<b>Analysis By</b>
11/4/96	2330	NA	19.9	26.3	QA Standard	A.M. Welcher
11/4/96	2225	NA	28.8	26.0	Water Truck	A.M. Welcher
11/4/96	2230	623	29.7	26.0	Discharge Line	A.M. Welcher
11/4/96	2330	643	29.3	26.0	Discharge Line	A.M. Welcher
11/5/96	0040	683	20.4	26.0	Discharge Line	A.M. Welcher
11/5/96	0145	703	30.5	26.1	Discharge Line	A.M. Welcher
11/5/96	0230	NA	20.0	25.7	QA Standard	A.M. Welcher
11/5/96	0145	NA	29.7	26.1	Water Truck	A.M. Welcher
11/5/96	0245	NA	28.9	25.7	Water Truck	A.M. Welcher
11/5/96	0245	743	29.8	25.7	Discharge Line	A.M. Welcher
11/5/96	0345	780	31.3	25.7	Discharge Line	A.M. Welcher
11/5/96	0445	790	31.7	25.9	Discharge Line	A.M. Welcher
11/5/96	0550	NA	20.0	25.6	QA Standard	A.M. Welcher
11/5/96	0545	820	31.4	26.1	Discharge Line	J. Wurtz
11/5/96	0615	840	30.7	25.6	Discharge Line	J. Wurtz
11/5/96	0700	860	36.6	25.7	Discharge Line	J. Wurtz
11/5/96	0730	880	38.7	25.7	Discharge Line	J. Wurtz
11/5/96	0800	900	42.4	25.7	Discharge Line	J. Wurtz
11/5/96	0845	NA	20.1	20.1	QA Standard	J. Wurtz
11/5/96	0830	NA	43.1	25.8	Water Truck	J. Wurtz
11/5/96	0830	920	47.5	25.7	Discharge Line	J. Wurtz
11/5/96	0900	NA	47.5	25.9	Water Truck	J. Wurtz
11/5/96	0915	940	45.9	25.9	Discharge Line	J. Wurtz
11/5/96	1110	960	43.4	25.9	Discharge Line	J. Wurtz
11/5/96	1330	NA	20.2	25.8	QA Standard	J. Wurtz
11/5/96	1135	980	44.9	26.0	Discharge Line	J. Wurtz
11/5/96	1210	1000	45.4	26.0	Discharge Line	J. Wurtz
11/5/96	1305	1023	41.5	25.9	Discharge Line	J. Wurtz
11/5/96	1320	1043	39.5	25.9	Discharge Line	J. Wurtz
11/5/96	1400	1060	39.4	25.9	Discharge Line	J. Wurtz
11/5/96	1430	1083	44.5	25.9	Discharge Line	J. Wurtz
11/5/96	1800	NA	23.9	25.0	QA Standard	P. Gallo
11/5/96	1930	NA	20.0	25.4	QA Standard	A.M. Welcher
11/5/96	1500	NA	36.7	25.4	Water Truck	A.M. Welcher
11/5/96	1500	1090	39.0	25.4	Discharge Line	A.M. Welcher
11/5/96	1600	1120	26.7	25.4	Discharge Line	A.M. Welcher
11/5/96	1640	1143	29.6	25.4	Discharge Line	A.M. Welcher
11/5/96	1710	1163	27.5	25.4	Discharge Line	A.M. Welcher
11/5/96	2115	NA	20.0	25.9	QA Standard	A.M. Welcher
11/5/96	1740	1183	30.8	25.9	Discharge Line	A.M. Welcher
11/5/96	1820	NA	29.9	25.9	Water Truck	A.M. Welcher
11/5/96	1820	1203	34.8	25.9	Discharge Line	A.M. Welcher
11/5/96	1905	NA	21.1	25.9	Water Truck	A.M. Welcher
11/5/96	1905	1223	23.6	25.9	Discharge Line	A.M. Welcher
11/5/96	2400	NA	20.0	25.7	QA Standard	A.M. Welcher
11/5/96	2005	1243	19.8	25.7	Discharge Line	A.M. Welcher
11/5/96	2105	1263	21.0	25.7	Discharge Line	A.M. Welcher
11/5/96	2200	NA	20.6	25.7	Water Truck	A.M. Welcher
11/5/96	2200	1283	18.5	25.7	Discharge Line	A.M. Welcher
11/5/96	2305	1303	18.4	25.7	Discharge Line	A.M. Welcher
11/6/96	0030	NA	20.0	25.3	QA Standard	A.M. Welcher
11/6/96	0230	1303	16.5	25.3	Circulating	A.M. Welcher

**Table 6-2**  
**HC-3 Water Level Measurements**

Well Name	Date	Depth to Fluid (ft)	Elevation (ft)	Notes
HC-3	06-Nov-96	1186	3895.52	H2O level approximate. Obtained by DRI using EC response in chemtool. Hole bridged at 1190 ft.
HC-3	09-Nov-96	1077.67	4003.85	H2O level meas. to top of casing (4.82 ft); located in elevators on drill table. Meas. adj. to GL.
HC-3	10-Nov-96	1107	3974.52	H2O level from temp. log from Century Geophysics after completion of circulation and clean-out.

**Table 6-3**  
**HC-3 List of Geophysical Logs**

<b>Well Name</b>	<b>Geophysical Log</b>	<b>Date Logged</b>	<b>Log Bottom (ft)</b>	<b>Log Top (ft)</b>	<b>Logging Company</b>
HC-3	3-Arm Caliper	11/8/96	1020.00	0.00	Century Geophysical
HC-3	Density/Resistivity/Neutron/Neutron Porosity	11/8/96	1023.90	0.00	Century Geophysical
HC-3	Deviation - magnetic	11/8/96	1015.00	0.00	Century Geophysical
HC-3	Deviation - gyroscopic	11/10/96	1132.60	0.00	Century Geophysical
HC-3	Spectra Gamma Ray (K, U, Th)	11/8/96	1023.10	0.00	Century Geophysical
HC-3	Temperature	11/10/96	1135.10	1002.80	Century Geophysical
HC-3	Downhole Video Camera	11/6/96	750.00	0.00	DRI

Note: Calibrations and repeat sections were performed per contract specifications.

**Table 6-4**  
**HC-3 Summary of Subsurface Investigation**  
**Samples**

Sample Number	Date Collected	Location	Sample Type	Depth (ft)	COC Number	Comments
PSC00001	10/2/96	HC-1	Cuttings	930	519811	Cuttings sample collected at HC-1 during drilling.
PSW00003	10/4/96	HC-1	Groundwater	920	519812	Groundwater sample from HC-1 Well Development...Full Lab QC
PSW00004	10/4/96	HC-1	Groundwater (dup)	920	519812	Duplicate of sample PSW00003
PSW00005	10/4/96	HC-1	Water (QC)	NA	519812	Equipment Rinsate sample
PSW00006	10/4/96	HC-1	Water (QC)	NA	519812	Field Blank sample
PSF00001	10/5/96	HC-1	Discharge Fluid	NA	519816	Composite sample collected at HC-1 Sump #1
PCX00001	11/3/96	HC-1	2nd Discharge Fluid	NA	519820	Additional fluids discharged into HC-1 Sump #1, 2nd composite sample collected.
PSC00002	10/16/96	HC-2	Cuttings	1253	519813	Cuttings sample from HC-2 taken during drilling.
PSW00007	10/21/96	HC-2	Groundwater	1173	519814	Groundwater sample from HC-2 Well Development.
PSF00003	10/20/96	HC-2	Discharge Fluid	NA	522037	Composite sample collected at HC-2 Sump #1.
PSC00003	11/5/96	HC-3	Cuttings	1255	519822	Cuttings sample from HC-3 taken during drilling.
PSW00008	11/14/96	HC-3	Groundwater	1104	519823	Groundwater sample from HC-3 Well Develop. Waiting on results.
PSF00005	11/12/96	HC-3	Discharge Fluid	NA	519824	Composite sample collected at HC-3, Sump #1.
PSC00004	10/23/96	HC-4	Cuttings	1250	519817	Cuttings sample collected at HC-4 during drilling.
PSW00009	11/7/96	HC-4	Groundwater	1130	519819	Groundwater sample from HC-4 using a discrete bailer.
PSF00007	10/24/96	HC-4	Discharge Fluid	NA	519818	Composite sample collected at HC-4, Sump #1

**Table 6-5a to 6-5e**  
**HC-3 Sample Results**  
 (Page 1 of 3)

**Table 6-5a**

Sample Location	Sample #	Sample Date	Matrix	Aluminum (mg/L) <sup>a</sup>	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)
HC-3	PSC0003	11/5/96	Cuttings	N/A <sup>b</sup>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-3	PSW00008	11/14/96	Groundwater	N/A	N/A	0.0018 (ND) <sup>c</sup>	0.0472	N/A	N/A	0.0006 (ND)	N/A	0.0394
HC-3	PSF00005	11/12/96	Sump	N/A	N/A	0.0018 (ND)	0.138	N/A	N/A	0.0006 (ND)	N/A	0.0032

**Table 6-5b**

Sample Location	Sample #	Sample Date	Matrix	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Lithium (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
HC-3	PSC0003	11/5/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-3	PSW00008	11/14/96	Groundwater	N/A	N/A	N/A	0.0414	N/A	N/A	N/A	0.00024	N/A
HC-3	PSF00005	11/12/96	Sump	N/A	N/A	N/A	0.0049	N/A	N/A	N/A	0.00016	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below the detection limit.

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 6-5a to 6-5e**  
**HC-3 Sample Results**  
 (Page 2 of 3)

**Table 6-5c**

Sample Location	Sample #	Sample Date	Matrix	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Strontium (mg/L)	Thallium (mg/L)
HC-3	PSC0003	11/5/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-3	PSW00008	11/14/96	Groundwater	N/A	N/A	0.0028 (ND)	N/A	0.0015 (ND)	N/A	N/A	N/A
HC-3	PSF00005	11/12/96	Sump	N/A	N/A	0.0028 (ND)	N/A	0.0015 (ND)	N/A	N/A	N/A

**Table 6-5d**

Sample Location	Sample #	Sample Date	Matrix	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	Tritium (pCi/L) <sup>d</sup>	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Bismuth-214 (pCi/L)	Cesium-137 (pCi/L)
HC-3	PSC0003	11/5/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	ND <sup>f</sup> pCi/g <sup>e</sup>	0.18 (ND) pCi/g
HC-3	PSW00008	11/14/96	Groundwater	N/A	N/A	N/A	-372	163	39.9	ND	7.15 (ND)
HC-3	PSF00005	11/12/96	Sump	N/A	N/A	N/A	-30	17.5	6.62	ND	ND

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below the detection limit.

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 6-5a to 6-5e**  
**HC-3 Sample Results**  
 (Page 3 of 3)

**Table 6-5e**

Sample Location	Sample #	Sample Date	Matrix	Lead-212 (pCi/L)	Lead-214 (pCi/L)	Potassium-40 (pCi/L)	Thallium-208 (pCi/L)	Thorium-234 (pCi/L)
HC-3	PSC0003	11/5/96	Cuttings	0.31 pCi/g	0.70 pCi/g	41.7 pCi/g	0.23 pCi/g	ND pCi/g
HC-3	PSW00008	11/14/96	Groundwater	ND	ND	ND	ND	75.5
HC-3	PSF00005	11/12/96	Sump	ND	ND	ND	ND	ND

6-23

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below the detection limit.

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted.

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

## **7.0 Well HC-4 Summary of Operations**

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Well HC-4 was drilled to a depth of 397.15 m (1,303.0 ft) between October 20, 1996, and October 25, 1996. Five days were spent drilling and completing the installation of this well. Note that [Figures 7-1 through 7-10](#), cited in the following text, are located at the end of this section.

Prior to mobilization, all drilling equipment was decontaminated at the on-site decontamination pad using a combination of steam cleaning and high pressure washing. Decontaminated equipment was subjected to a radiological screening prior to mobilization to the drill site.

A 30.48-cm (12.0-in.) hole for the surface conductor was drilled using reverse air rotary reverse circulation techniques and a 30.48-cm (12-in.) downhole percussion hammer to a depth of 31.39 m (103 ft) bgs. A 21.91-cm (8.625-in.) carbon steel casing was installed in this hole and cemented to the surface using Type II cement without the requested 2 percent calcium chloride additive. The lack of calcium chloride resulted in an estimated ten additional hours waiting for the cement to cure.

The main hole was drilled from below the casing point to a TD of 397.15 m (1,303.0 ft) bgs using a 20.32-cm (8.0-in.) percussion hammer button bit and air rotary reverse circulation techniques. Drilling progressed smoothly during the advance of the main hole. Rates of penetration were high, ranging from 1.64 to 4.26 minutes per meter (0.5 to 1.3 minutes per foot). Some short delays to the drilling progress resulted from leaks/washouts of the discharge hose or cyclone; repairs were made quickly; and drilling resumed. [Figure 7-1](#) provides a summary of drilling parameters for the well. All figures and tables, cited in the text, are located at the end of this section.

Upon completion of drilling operations, the well was circulated for a short period of time. The drill pipe was then tripped out of the hole to a depth of 365.76 m (1,200.0 ft). After waiting for a period of one hour, the drilling assembly was tripped into the hole to a depth of 397.15 m (1,303.0 ft) to check for fill. No fill was encountered. The drilling assembly was then pulled from the borehole in preparation for geophysical logging.

Geophysical logging commenced on October 23, 1996, and was completed on October 24, 1996. Logging proceeded smoothly with all geophysical logging runs conducted to a depth of 394.41 m

(1,294.0 ft). The downhole video was completed to a depth of 317.91 m (1,043.0 ft); logging was not continued below this depth due to the turbidity of the fluid in the borehole.

### **7.1 Well HC-4 Geology**

Well HC-4 encountered a fractured, coarse-grained biotite granite of Cretaceous age throughout the drilled interval. Three significant fault/fracture zones were encountered in the well. The first was located between 134.11 to 146.30 m (440.0 to 480.0 ft), apparently related to the occurrence of an aplite dike. A second, broader fracture zone was encountered in the approximate interval of 243.84 to 274.32 m (800.0 to 900.0 ft); granitic rocks within this zone were also hydrothermally altered with the development of some clays and pervasive chloritization. This alteration assemblage is typical of those recognized along fracture and fault zones intruded by Tertiary-aged andesite dikes; however, no andesite was noted during the collection of cuttings during drilling operations. A lithologic log is provided as [Figure 7-2](#).

### **7.2 Well HC-4 Hydrology**

Several elements of hydrologic importance were monitored during and after the completion of Well HC-4. During drilling operations, two monitoring parameters were consistently compared: the volume of drilling fluids (water/foam) injected to facilitate drilling and volume of fluid produced as discharge to the surface during the same time. [Figure 7-3](#) illustrates the relationships between injected drilling fluids and drilling fluid produced at the surface.

In addition to these volumetric measurements, all drilling fluids injected into the borehole were tagged with a tracer solution of LiBr. The concentration of LiBr in solution was monitored on a regular basis to estimate groundwater production within the borehole. [Table 7-1](#) lists LiBr concentrations recorded in produced fluids.

Water production from the well was minimal; monitoring data and water-level recovery data suggest the well was capable of producing approximately 2.8 to 3.8 L/min (0.75 to 1.0 gpm). During several instances, the well was capable of intermittent production on the order of 11.4 to 18.8 L/min (3.0 to 5.0 gpm). These somewhat higher readings suggest groundwater production from perched water zones along fault or fracture zones. These zones were of limited impact as their storage capacities were generally small, and as they were exhausted, their contribution of water to the well bore decreased.

Water-level monitoring was conducted during the construction of the well and continued after completion using transducers set by DRI. The static water level for Well HC-4 is approximately

317.20 m (1,040.0 ft) bgs. [Table 7-2](#) provides water levels obtained for the term of IT involvement in PSA field work.

### **7.3 Well HC-4 Geophysical Surveys**

Upon completion of drilling to the TD of 397.15 m (1,303.0 ft) and after a short session of well development, a suite of downhole geophysical surveys was run within the borehole. Geophysical logging operations were conducted over the period of two days on October 23, 1996, and October 24, 1996. No operational problems were encountered.

[Table 7-3](#) provides a summary of the geophysical logs run for the well and the corresponding logged intervals. Additional, specialized logging was performed by DRI as part of their scientific work scope. [Figures 7-4 to 7-7](#) provide condensed illustrations of log traces for Well HC-4.

Deviation surveys conducted within the casing and the open borehole indicate the borehole is deviated 7.7 degrees vertically in a northeast direction. The deviation of the hole placed the bottom of the hole 32.16 m (105.5 ft) northeast of the collar and resulted in a true vertical depth of 392.65 m (1,288.23 ft) bgs.

### **7.4 Well HC-4 Radiologic Monitoring**

Monitoring of discharge effluent from drilling was conducted as specified in the Project Shoal SSHASP (DOE/NV, 1996b) and the FMP for the Project Shoal Area Offsite Subproject (DOE/NV, 1996c). Regular radiologic monitoring of discharged drilling effluents, including both fluids and solids, was conducted by Bechtel Nevada radiation control technicians.

Samples for further on-site lab analysis were screened using hand held instruments at the time of sample collection. Effluents were further analyzed for tritium and other radionuclides using on-site laboratory monitoring equipment. Tritium activities from fluid and swiped samples were recorded using a Packard Liquid Scintillation instrument. Other radionuclides were analyzed using Canberra gamma spectroscopy instrumentation.

Well HC-4 drilling effluents were found to contain only natural background levels of tritium and other radionuclides based on results of field monitoring. [Figure 7-8](#) provides a profile of tritium encountered from fluids generated during drilling.

Radiologic monitoring of Century Geophysical's downhole geophysical logging tools detected an elevated alpha count on their Spectral Gamma Ray tool after being removed from the borehole.

The tool was swiped again to confirm initial readings; the second readings were approximately 30 percent of initial readings. The rapid dissipation of activity indicated that readings could be attributed to naturally occurring radon gases.

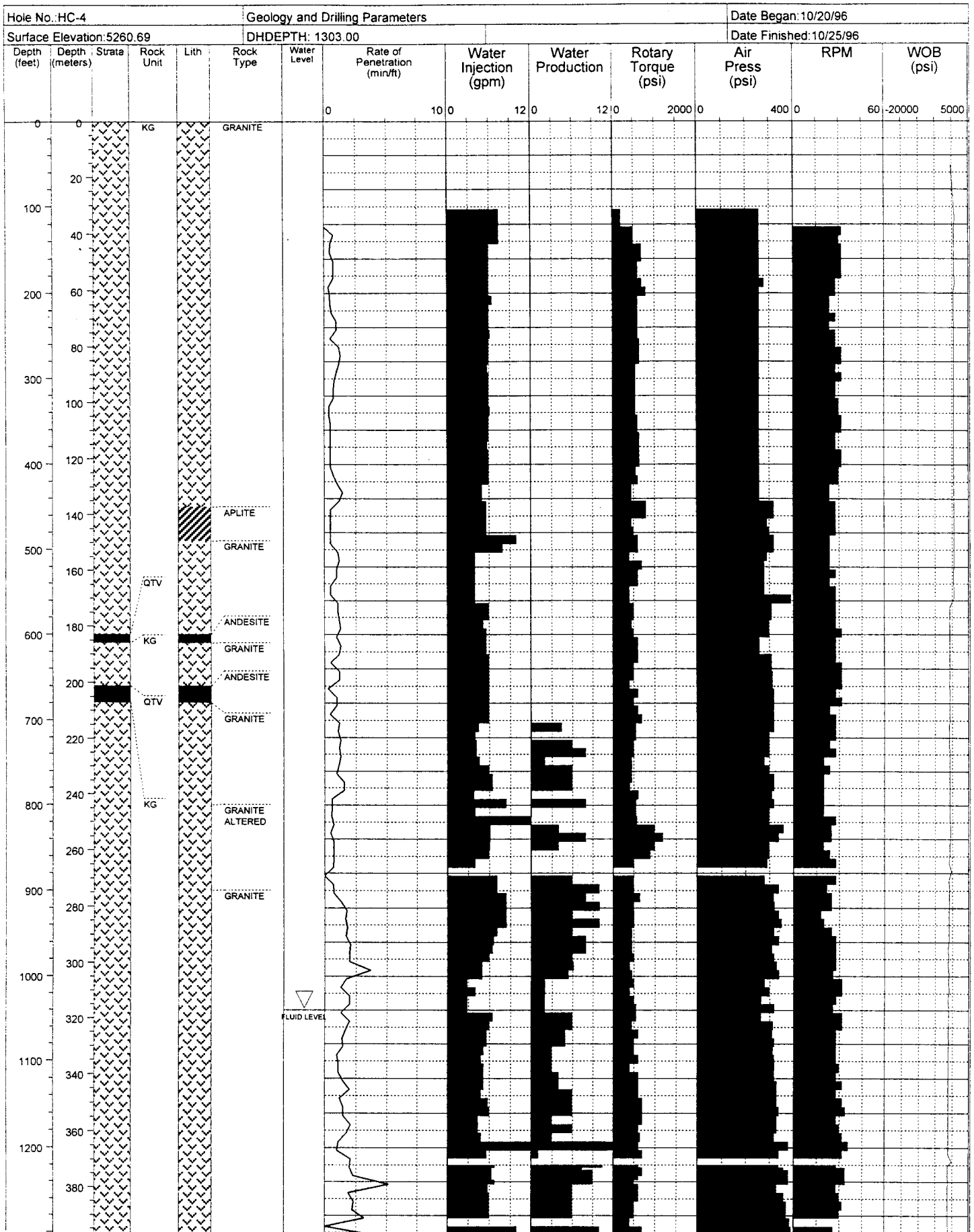
### **7.5 Well HC-4 Construction**

Construction of Well HC-4 included the drilling of a 30.48-cm (12.0-in.) surface borehole to a depth of 31.39 m (103.0 ft). Conductor casing comprised of 21.91-cm (8.625-in.) carbon steel was installed in the 30.48-cm (12.0-in.) hole. Bow-type centralizers were placed approximately 1.52 m (5.0 ft) from the bottom of the casing and then centered at the surface. The conductor casing was cemented to the surface using Type II neat cement without the 2 percent calcium chloride as an additive.

Intermediate 13.97-cm (5.50-in.) carbon steel casing was installed in the completed 20.32-cm (8-in.) borehole and set at a depth of 308.76 m (1,013.0 ft) bgs. Intermediate casing was installed without specified centralizers or cement baskets due to adverse borehole conditions. Intermediate casing was suspended on landing straps secured to the surface conductor casing. [Figure 7-9](#) provides a schematic view of the final completion. The surface completion for the well head is illustrated in [Figure 7-10](#).

### **7.6 Well HC-4 Sampling**

Samples for analytical analysis were collected from fluids and cuttings as specified in the *Field Instructions for Project Shoal Area Surface and Subsurface Investigation, Churchill County, Nevada* (IT, 1996) and the FMP for the Project Shoal Area Offsites Subproject (DOE/NV, 1996c). The sample type and analytical results of these samples are shown in [Tables 7-4 and 7-5](#).



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

**Figure 7-1**  
**Summary of Well HC-4 Drilling Parameters**

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

Shoal Project  
Churchill Co Nevada  
Project No. 764044.03.07.00.00  
IT Corporation Offsites Project  
Lithologic Descriptions by Well

Well ID. HC-4                      **GRANITE**                      0.00    200.00    jaw 10/21/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (10%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (30%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm. Spotty fracture stains of ocherous yellow limonite through out interval.

Well ID. HC-4                      **GRANITE**                      200.00    450.00    jaw 10/21/96  
Granite, mixed grayish white to creamy buff white, pervasive yellow to yellow staining. porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (20%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (20%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm.

Well ID. HC-4                      **APLITE**                      450.00    490.00    jaw 10/21/96  
Aplite, creamy gray white to white, principally massive grayish white kspar with prominent cleavage surfaces, (70%) the remainder of the rock appears to be comprised of blebs of transl gray qtz, mostly anhed. Minor black to green black biotite (possible cross contamination from up hole. Interval 460-470 is contains much pinkish clay. Cuttings and clay suggest a fault fracture zone.

Well ID. HC-4                      **GRANITE**                      490.00    600.00    jaw 10/21/96  
Granite, mixed grayish white to creamy buff white, strong pervasive yellow to yellow staining. porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (20%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (20%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm.

Well ID. HC-4                      **ANDESITE**                      600.00    610.00    jaw 10/21/96  
Andesite, Dark olive green to dark grayish green, porphyritic, black phenocrysts of pyroxene?? possible olivine .2-1.0 mm, groundmass is aphanitic to a very fine grained sandy matrix with no identifiable minerals.

Well ID. HC-4                      **GRANITE**                      610.00    660.00    jaw 10/21/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (10%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (30%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm. Good cuttings quality 3-10mm.

Well ID. HC-4                      **ANDESITE**                      660.00    680.00    jaw 10/21/96  
Andesite, Dark olive green to dark grayish green, porphyritic, black phenocrysts of pyroxene?? possible olivine .2-1.0 mm, groundmass is aphanitic to a very fine grained sandy matrix with no identifiable minerals.

Well ID. HC-4                      **GRANITE**                      680.00    800.00    jaw 10/21/96  
Granite, mixed grayish white to creamy buff white, strong pervasive yellow to yellow staining. porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (20%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (20%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm.

**Figure 7-2**  
**Well HC-4 Lithologic Descriptions**  
(Page 1 of 2)

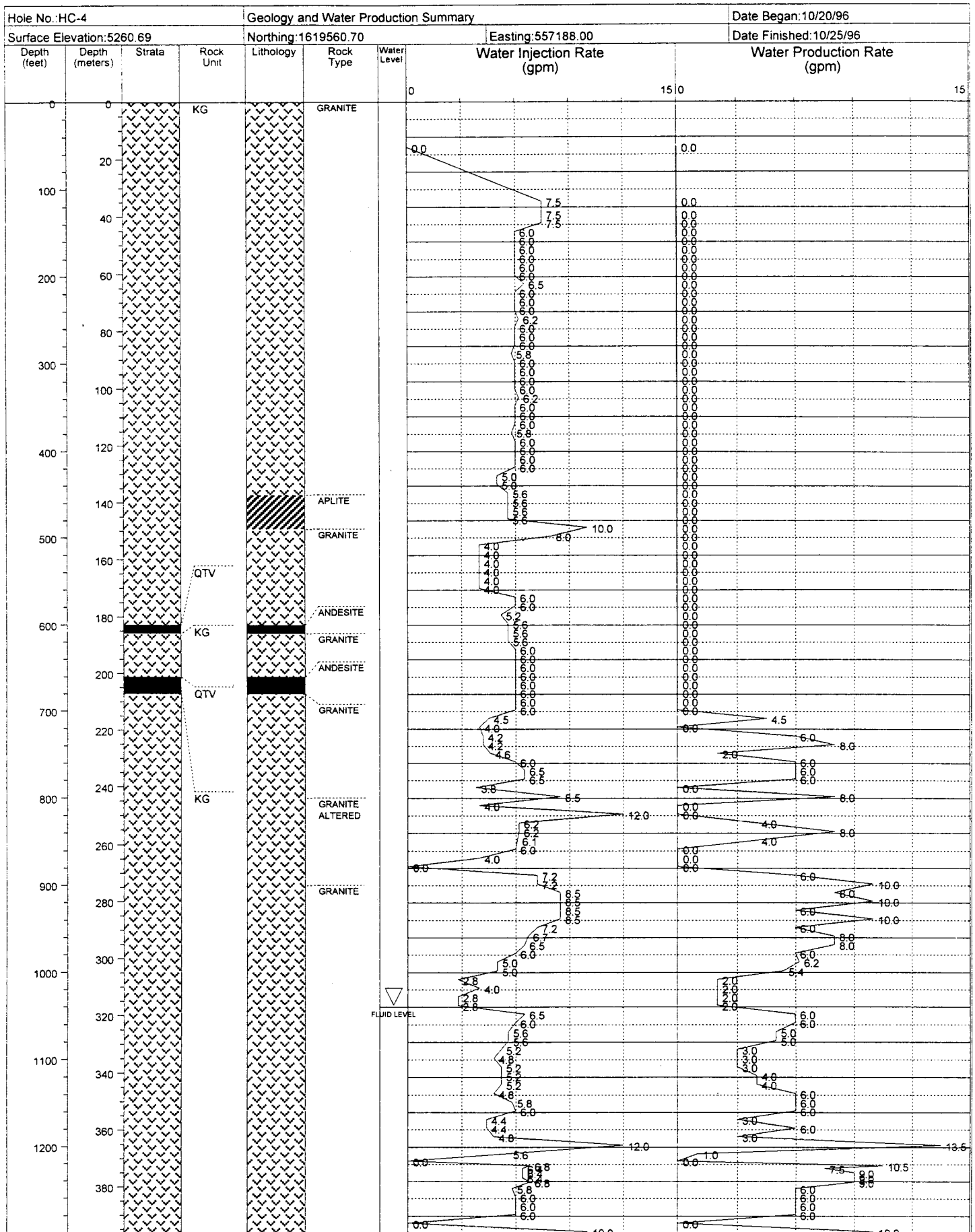
Well ID. HC-4                      GRANITE                      800.00    900.00    jaw 10/21/96  
Altered Granite, fracture fault zone with mixed cutting of granite and andesite as noted in previous intervals. Abundant clay as pinkish to pinkish grey balls and irregular masses. Very likely fault zone that has been filled/intruded by thin dikes or bodies of andesite.

Well ID. HC-4                      GRANITE                      900.00    1050.00    jaw 10/21/96  
Granite, mixed grayish white to creamy buff white, locally strong pervasive yellow to yellow staining. porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (20%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (20%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm.

Well ID. HC-4                      GRANITE                      1050.00    1250.00    jaw 10/21/96  
Granite, mixed grayish white to creamy yellowish white, locally strong pervasive yellow to yellow staining. porphyritic, abundant black to greenish black biotite xls <1.0 mm altering locally to chlorite also noted as irregular masses to 5 mm (20%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (20%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm. Large cuttings up to 15mm

Well ID. HC-4                      GRANITE                      1250.00    1303.00    jaw 10/21/96  
Granite, mottled grayish white to creamy buff white, porphyritic, abundant black to greenish black biotite xls <1.0 mm also noted as irregular masses to 5 mm (10%), groundmass comprised of medium to coarse grained clear to translucent gray quartz, (30%), milky white to pale pink gray kspar (40%), xl to 15mm. also noted as porphyritic xl of microcline xl up to 15mm (20%), minor anhedral xl of plagioclase (<10%) Accessory magnetite as isolated blebs and anhed xls < 1mm.

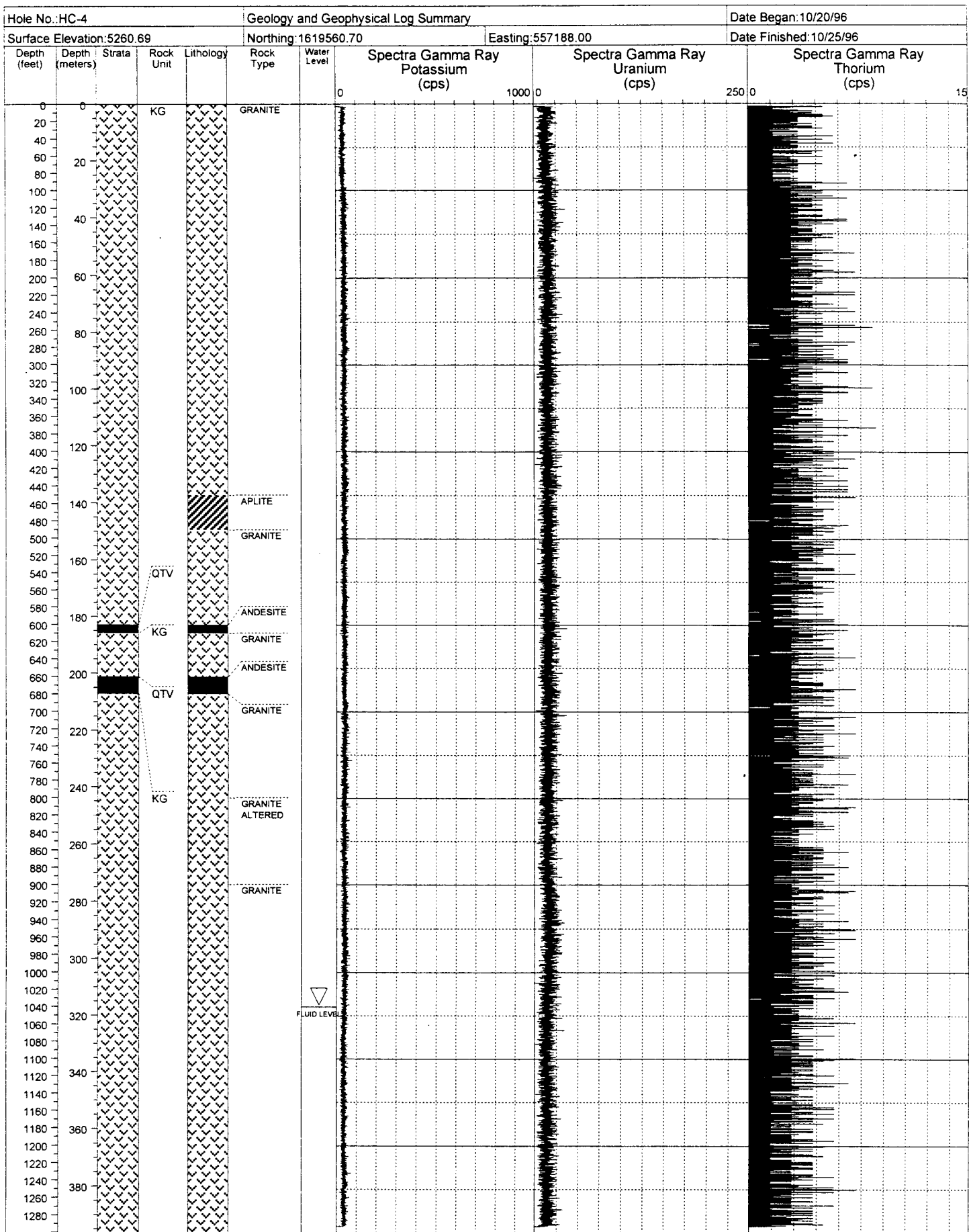
**Figure 7-2**  
**Well HC-4 Lithologic Descriptions**  
(Page 2 of 2)



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

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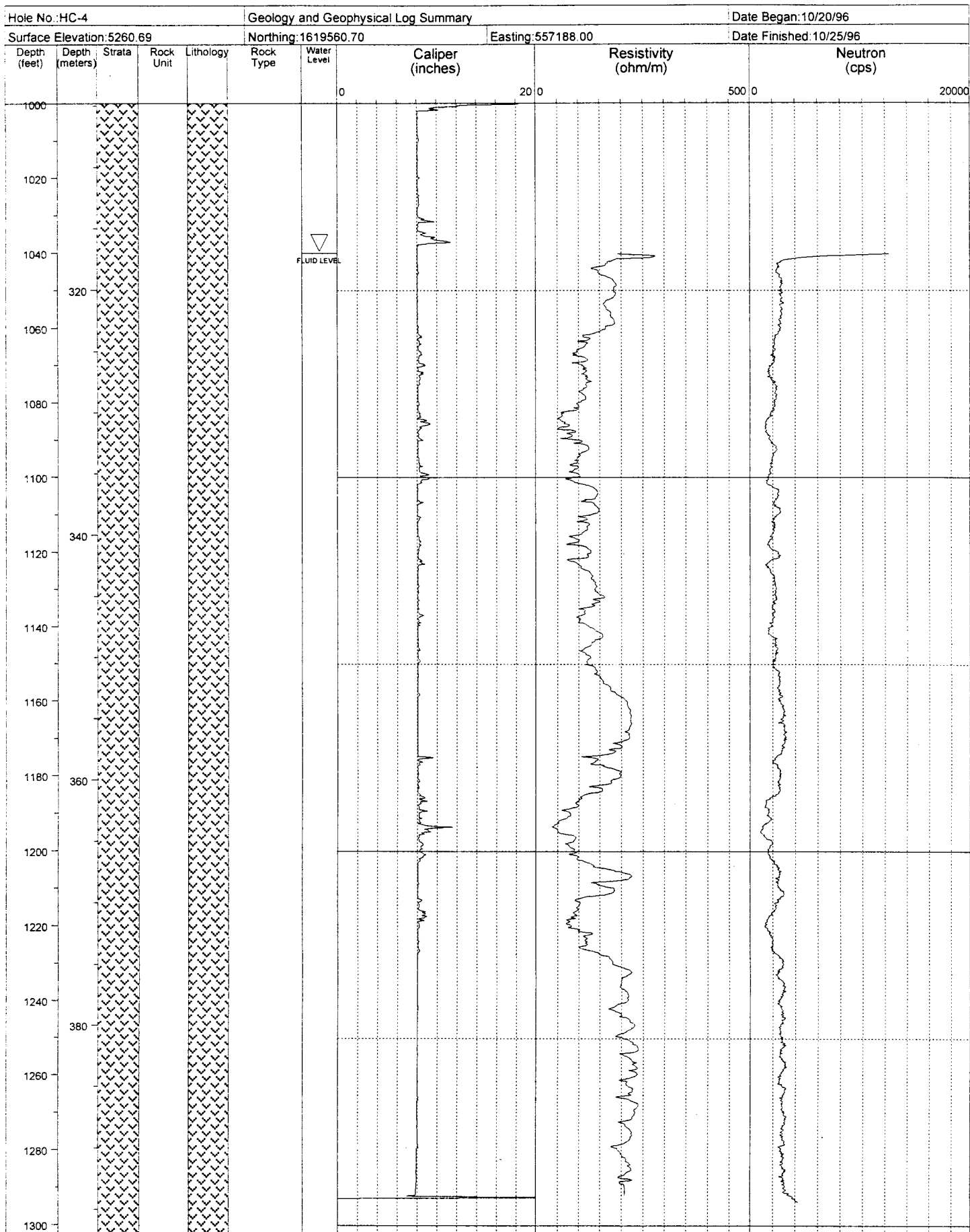
**Figure 7-3**  
**HC-4 Fluid Injection versus Production Diagram**



Logged By: Century Geophysics/DRI  
Drilling Co.: Beylik Drilling Services  
Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
Project Shoal  
Project No. 764044.03.07.00.00

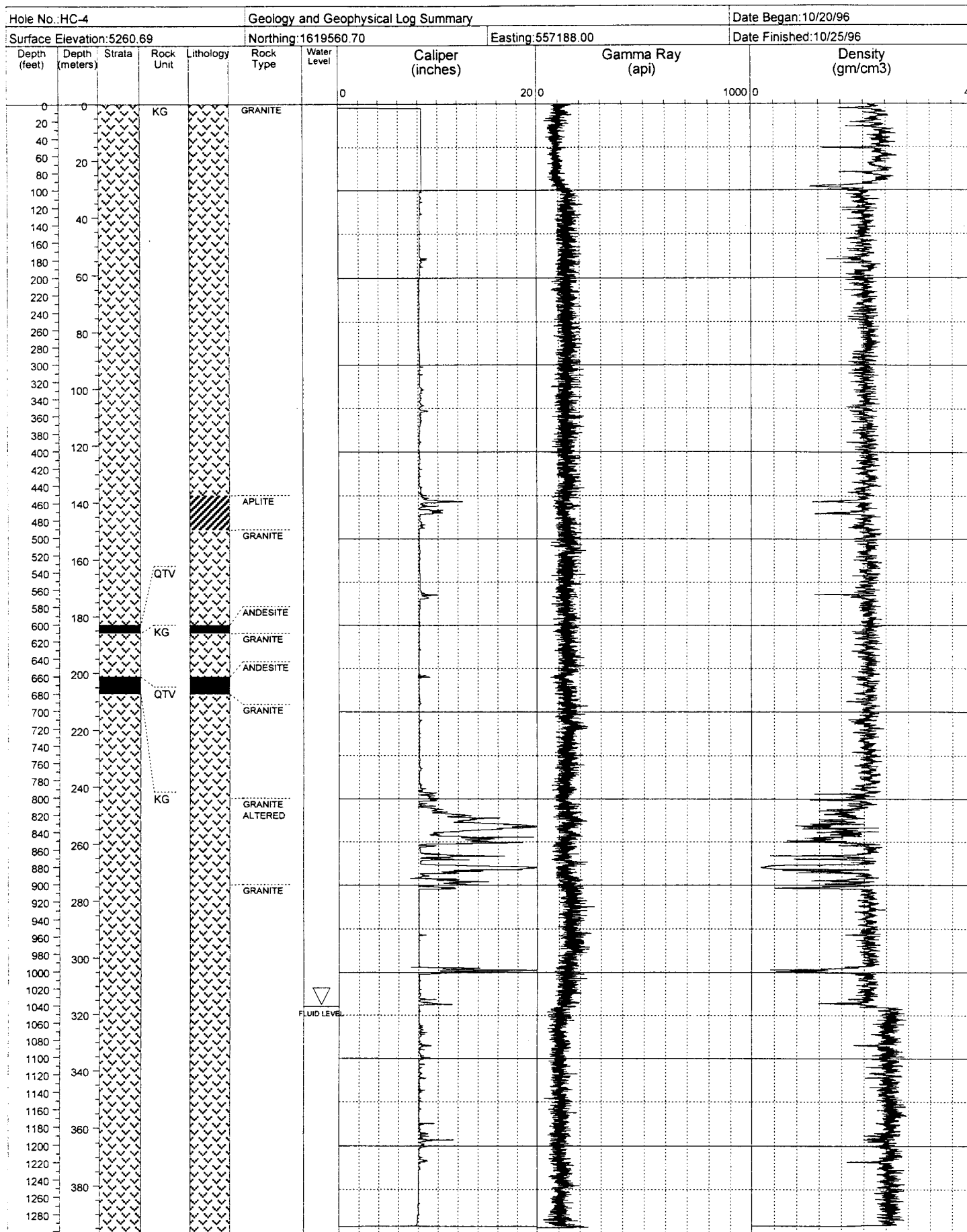
**Figure 7-4**  
**HC-4 Geophysical Log Traces of Spectra Gamma Ray**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

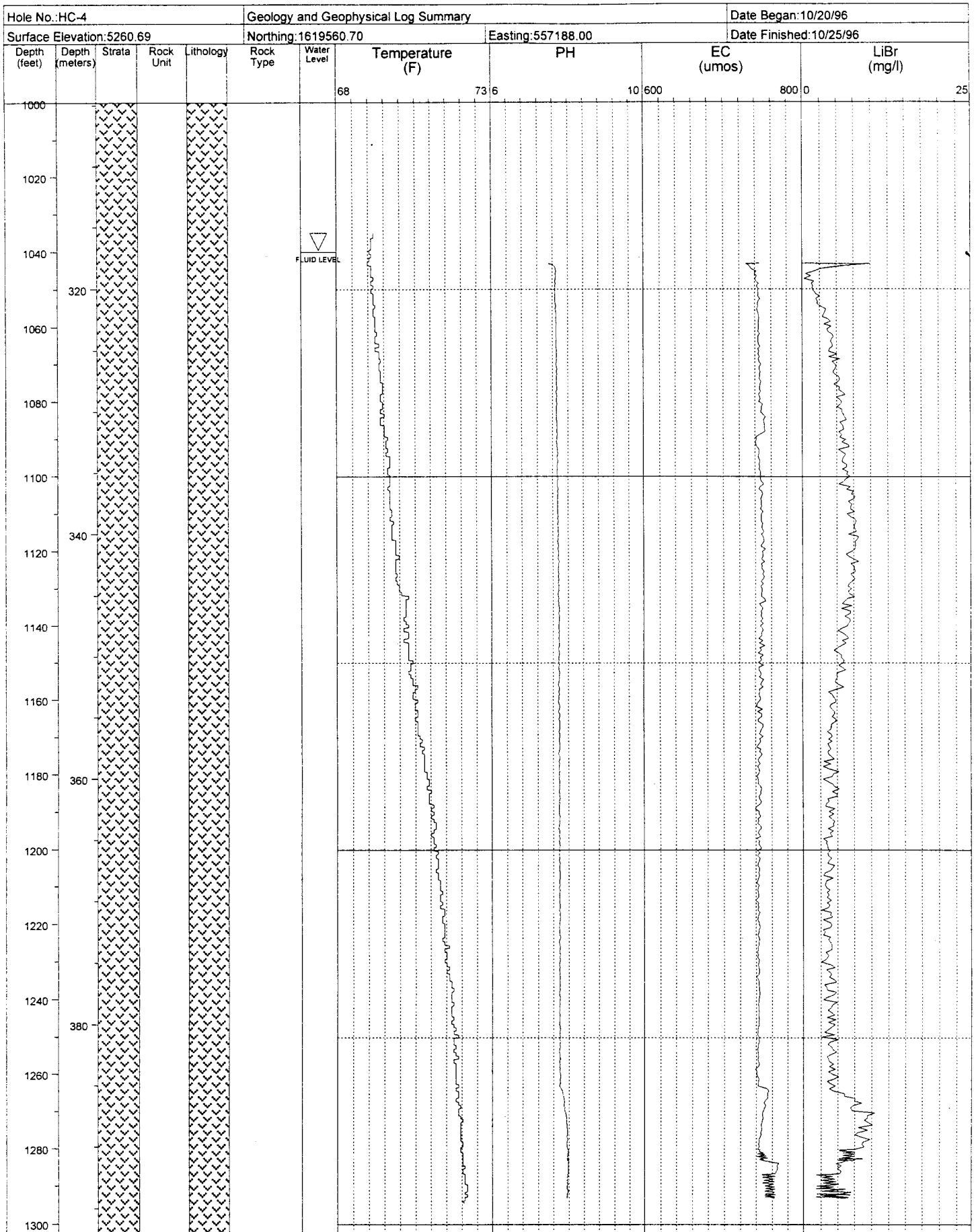
**Figure 7-5**  
**HC-4 Geophysical Log Traces of Caliper, Resistivity, Neutron**



Logged By: Century Geophysics/DRI  
 Drilling Co.: Beylik Drilling Services  
 Drilling Method: Air Rotary/ Reverse Circulation

IT CORPORATION  
 Project Shoal  
 Project No. 764044.03.07.00.00

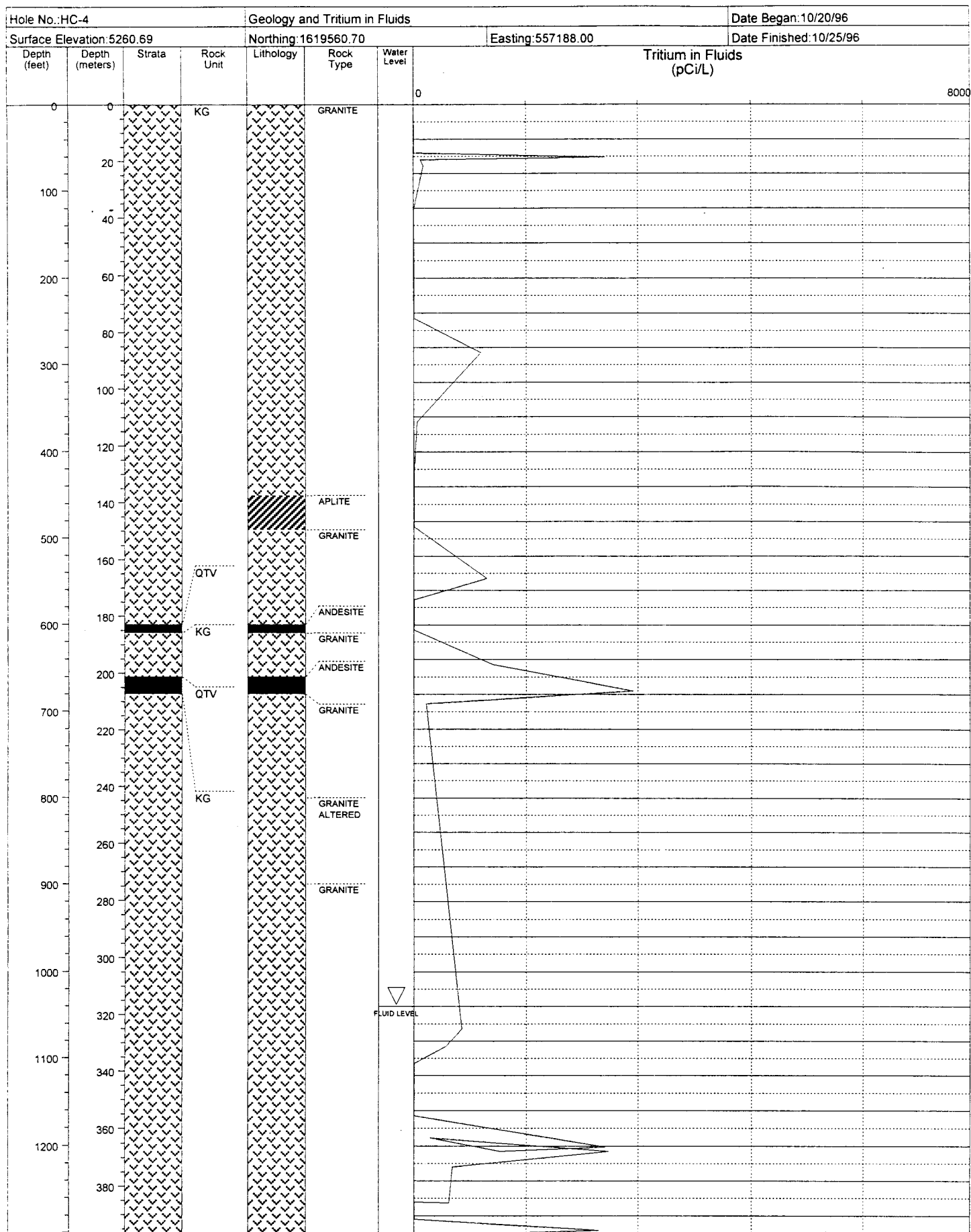
**Figure 7-6**  
**HC-4 Geophysical Log Traces of Caliper, Gamma Ray, Density**

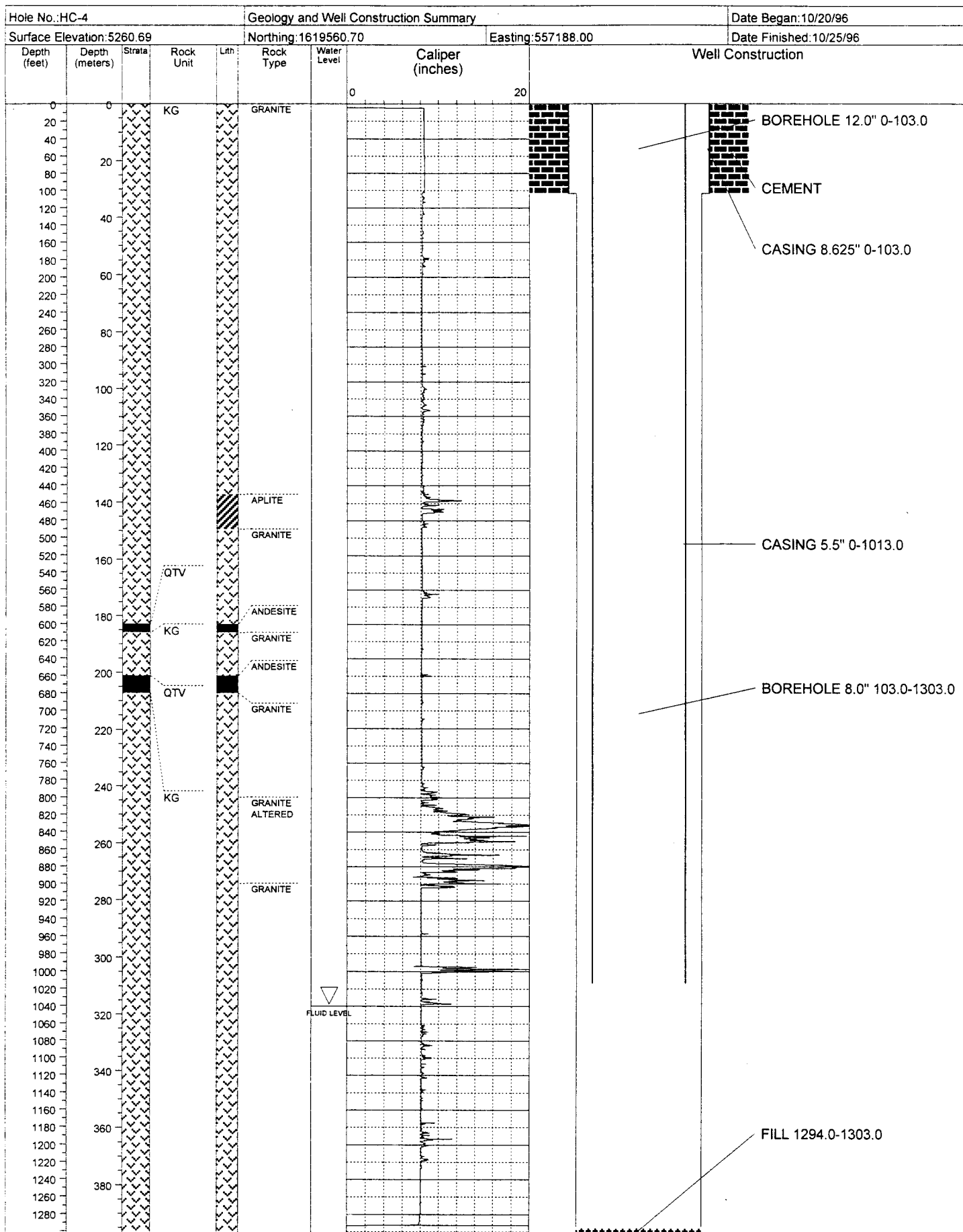


Logged By: Century Geophysics/DRI  
Drilling Co.: Beylik Drilling Services  
Drilling Method: Air Rotary/ Reverse Circulation

**Figure 7-7**  
**HC-4 Geophysical Log Traces of Chemtool**

IT CORPORATION  
Project Shoal  
Project No. 764044.03.07.00.00





Logged By: Century Geophysics/DRI

Drilling Co.: Beylik Drilling Services

Drilling Method: Air Rotary/ Reverse Circulation

**Figure 7-9**

**HC-4 Subsurface Well Completion Diagram**

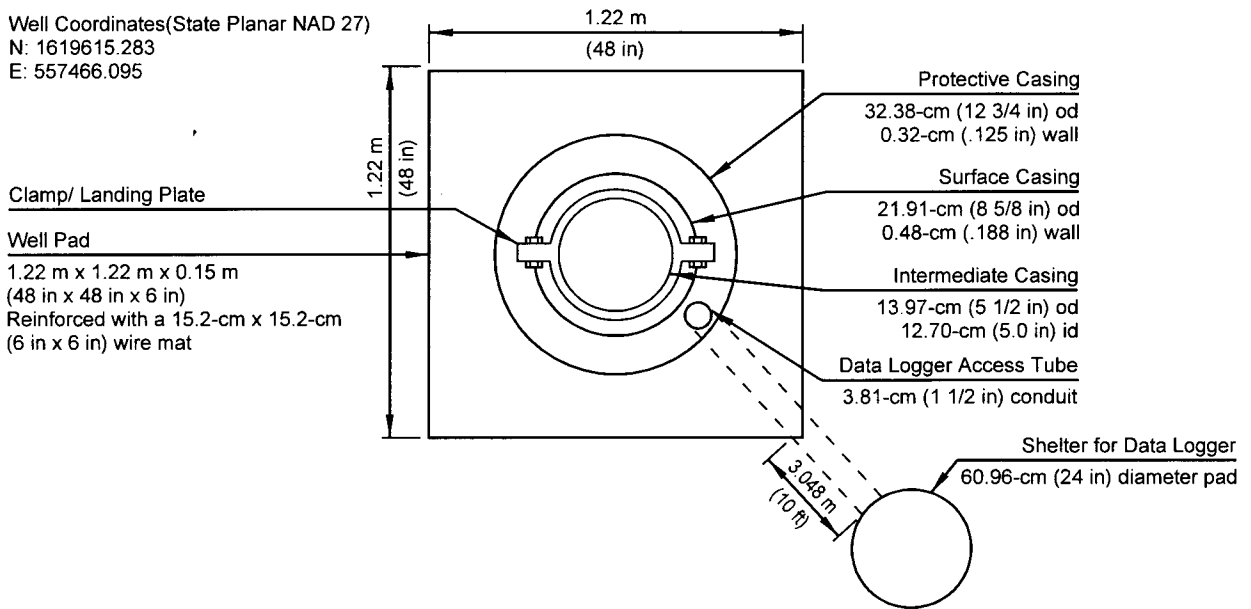
**IT CORPORATION**

Project Shoal

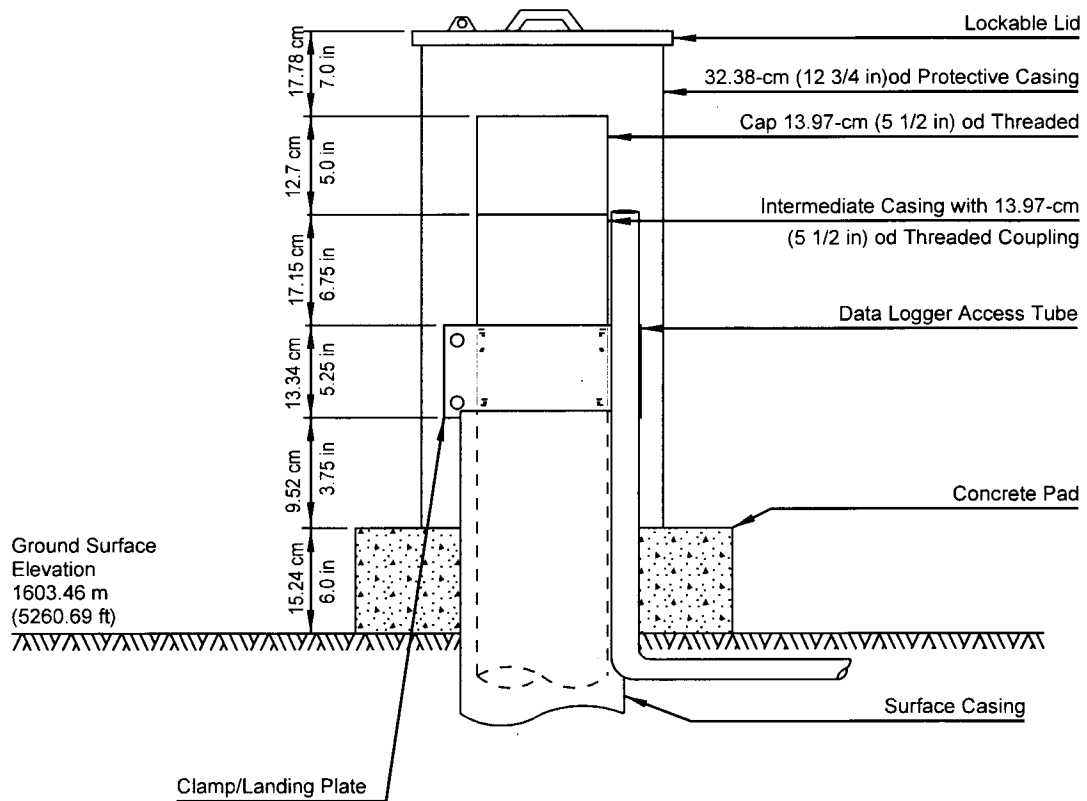
Project No. 764044.03.07.00.00



Well Coordinates(State Planar NAD 27)  
 N: 1619615.283  
 E: 557466.095



**Plan View**



**Profile View**

**Figure 7-10  
 HC-4 Well Head Completion Diagram**

**Table 7-1**  
**HC-4 Lithium Bromide Concentrations**

Date mm/dd/yy	Time (24 hrs)	Depth (ft)	Sample Conc. (mg/L)	Sample Temp (C°)	Sample Source	Analysis By
10/22/96	0630	NA	20.3	24.0	QCCS (20 mg/L)	R. Peterson
10/22/96	0540	NA	28.7	19.5	Water Truck	R. Peterson
10/22/96	0540	675	27.1	22.0	Discharge Line (DL)	R. Peterson
10/22/96	0605	NA	26.7	20.9	WT	R. Peterson
10/22/96	0605	690	25.6	22.6	DL	R. Peterson
10/22/96	1100	803	27.5	22.4	DL	J. Wurtz
10/22/96	1105	NA	19.9	25.3	QCCS (20 mg/L)	J. Wurtz
10/22/96	1106	NA	27.7	21.7	WT	J. Wurtz
10/22/96	1108	823	27.4	21.4	DL	J. Wurtz
10/22/96	1135	NA	21.9	24.8	WT	J. Wurtz
10/22/96	1145	843	23.2	25.1	DL	J. Wurtz
10/22/96	1120	863	20.4	25.3	DL	J. Wurtz
10/22/96	1320	NA	20.0	25.0	QCCS (20 mg/L)	J. Wurtz
10/22/96	1220	875	22.0	25.1	DL	J. Wurtz
10/22/96	1300	900	22.0	25.1	DL	J. Wurtz
10/22/96	1335	NA	29.0	25.4	WT	J. Wurtz
10/22/96	1330	920	35.4	25.2	DL	J. Wurtz
10/22/96	1435	NA	27.7	25.2	WT	J. Wurtz
10/22/96	1530	NA	20.3	25.1	QCCS (20 mg/L)	J. Wurtz
10/22/96	1430	940	32.2	25.5	DL	J. Wurtz
10/22/96	1530	960	30.3	25.5	DL	J. Wurtz
10/22/96	1630	980	28.8	25.3	DL	J. Wurtz
10/22/96	1715	NA	28.5	25.6	WT	J. Wurtz
10/22/96	1715	1000	29.5	25.2	DL	J. Wurtz
10/22/96	2100	NA	19.9	25.5	QCCS (20 mg/L)	A.M. Welcher
10/22/96	1810	1025	30.3	25.0	DL	A.M. Welcher
10/22/96	1830	1043	31.2	25.2	DL	A.M. Welcher
10/22/96	2030	NA	34.6	25.0	WT	A.M. Welcher
10/22/96	2030	1065	28.3	25.4	DL	A.M. Welcher
10/22/96	2105	1085	30.0	25.4	DL	A.M. Welcher
10/22/96	2350	NA	20.0	25.3	QCCS (20 mg/L)	A.M. Welcher
10/22/96	2130	NA	33.1	25.3	WT	A.M. Welcher
10/22/96	2130	1105	23.1	25.3	DL	A.M. Welcher
10/22/96	2235	1125	30.6	25.3	DL	A.M. Welcher
10/22/96	2315	1145	30.7	25.3	DL	A.M. Welcher
10/23/96	0000	1165	29.1	25.3	DL	A.M. Welcher
10/23/96	0010	NA	19.8	25.3	QCCS (20 mg/L)	A.M. Welcher
10/23/96	0345	NA	20.5	26.5	QCCS (20 mg/L)	R. Peterson
10/23/96	0050	1185	28.9	26.0	DL	R. Peterson
10/23/96	0225	1200	30.6	26.1	DL	R. Peterson
10/23/96	0325	NA	33.5	25.8	WT	R. Peterson
10/23/96	0325	1205	28.9	26.0	DL	R. Peterson
10/23/96	0425	1190	24.7	25.7	DL	A.M. Welcher
10/23/96	0600	NA	19.9	26.1	QCCS (20 mg/L)	A.M. Welcher
10/23/96	0500	1205	24.7	26.2	DL	J. Wurtz
10/23/96	0600	1223	36.4	26.1	DL	J. Wurtz
10/23/96	0700	1243	35.5	26.0	DL	J. Wurtz
10/23/96	0800	1243	33.6	25.8	DL	J. Wurtz
10/23/96	0900	1263	30.8	26.0	DL	J. Wurtz
10/23/96	1130	NA	20.2	26.0	QCCS (20 mg/L)	J. Wurtz
10/23/96	0920	NA	30.3	26.1	WT	J. Wurtz
10/23/96	1000	1283	21.0	24.3	DL	P. Gallo
10/23/96	1000	NA	46.4	22.5	WT	P. Gallo
10/23/96	1220	NA	34.9	22.0	WT	P. Gallo
10/23/96	1220	1295	40.5	23.9	DL	P. Gallo
10/23/96	1315	NA	39.0	26.0	WT	J. Saavedra
10/23/96	1315	1303	38.8	25.1	DL	J. Saavedra

**Table 7-2**  
**HC-4 Water Level Measurements**

Well Name	Date	Depth to Fluid (ft)	Elevation (ft)	Notes
HC-4	23-Oct-96	1045.8	4214.89	Water level obtained immediately after development by IT using a solinst tape down drill pipe.
HC-4	24-Oct-96	1040	4220.69	Fluid level picked off Century Geophysical neutron log, measured from GL.
HC-4	24-Oct-96	1040	4220.69	Fluid level obtained from Century Geophysical temperature log using a datum of GL.
HC-4	24-Oct-96	1044.6	4216.09	Fluid level to ground surface. Measurement obtained by DRI using the Chemtool.
HC-4	01-Nov-96	1044.91	4215.78	DRI measurement of water level using downhole video camera.
HC-4	07-Nov-96	1041.96	4218.73	Water level was obtained by DRI using the EC Temperature tool. Meas. from GL.
HC-4	13-Nov-96	1040	4220.69	Approximate water level obtained with the DRI video camera. Measured from GL.

**Table 7-3**  
**HC-4 List of Geophysical Logs**

<b>Well Name</b>	<b>Geophysical Log</b>	<b>Date Logged</b>	<b>Log Bottom (ft)</b>	<b>Log Top (ft)</b>	<b>Logging Company</b>
HC-4	3-Arm Caliper	10/24/96	1292.90	4.70	Century Geophysical
HC-4	Density/Resistivity/Neutron/Neutron Porosity	10/24/96	1294.00	0.00	Century Geophysical
HC-4	Deviation - magnetic	10/24/96	1294.40	3.30	Century Geophysical
HC-4	Spectra Gamma Ray (K, U, Th)	10/24/96	1292.50	3.10	Century Geophysical
HC-4	Temperature	10/24/96	1294.40	0.00	Century Geophysical
HC-4	Acoustic Borehole Televiwer	10/24/96	1289.98	1034.94	Century Geophysical
HC-4	Chemtool	10/25/96	1295.00	1045.00	DRI
HC-4	Downhole Video Camera	10/23/96	1043.00	0.00	DRI

Note: Calibrations and repeat sections were performed per contract specifications.

**Table 7-4**  
**HC-4 Summary of Subsurface Investigation Samples**

Sample Number	Date Collected	Location	Sample Type	Depth (ft)	COC <sup>a</sup> Number	Comments
PSC00001	10/2/96	HC-1	Cuttings	930	519811	Cuttings sample collected at HC-1 during drilling.
PSW00003	10/4/96	HC-1	Groundwater	920	519812	Groundwater sample from HC-1 Well Development...Full Lab QC
PSW00004	10/4/96	HC-1	Groundwater (dup)	920	519812	Duplicate of sample PSW00003
PSW00005	10/4/96	HC-1	Water (QC)	NA	519812	Equipment Rinsate sample
PSW00006	10/4/96	HC-1	Water (QC)	NA	519812	Field Blank sample
PSF00001	10/5/96	HC-1	Discharge Fluid	NA	519816	Composite sample collected at HC-1 Sump #1
PCX00001	11/3/96	HC-1	2nd Discharge Fluid	NA	519820	Additional fluids discharged into HC-1 Sump #1, 2nd composite sample collected.
PSC00002	10/16/96	HC-2	Cuttings	1253	519813	Cuttings sample from HC-2 taken during drilling.
PSW00007	10/21/96	HC-2	Groundwater	1173	519814	Groundwater sample from HC-2 Well Development.
PSF00003	10/20/96	HC-2	Discharge Fluid	NA	522037	Composite sample collected at HC-2 Sump #1.
PSC00003	11/5/96	HC-3	Cuttings	1255	519822	Cuttings sample from HC-3 taken during drilling.
PSW00008	11/14/96	HC-3	Groundwater	1104	519823	Groundwater sample from HC-3 Well Develop. Waiting on results.
PSF00005	11/12/96	HC-3	Discharge Fluid	NA	519824	Composite sample collected at HC-3, Sump #1.
PSC00004	10/23/96	HC-4	Cuttings	1250	519817	Cuttings sample collected at HC-4 during drilling.
PSW00009	11/7/96	HC-4	Groundwater	1130	519819	Groundwater sample from HC-4 using a discrete bailer.
PSF00007	10/24/96	HC-4	Discharge Fluid	NA	519818	Composite sample collected at HC-4, Sump #1

<sup>a</sup>Chain of Custody

**Table 7-5a to 7-5f**  
**HC-4 Sample Results**  
 (Page 1 of 3)

**Table 7-5a**

Sample Location	Sample #	Sample Date	Matrix	Aluminum (mg/L) <sup>a</sup>	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)
HC-4	PSC00004	10/23/96	Cuttings	N/A <sup>b</sup>	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-4	PSW00009	11/7/96	Groundwater	N/A	N/A	0.0018 (ND) <sup>c</sup>	0.0557	N/A	N/A	0.0006 (ND)	N/A	0.0441
HC-4	PSF00007	10/24/96	Sump	N/A	N/A	0.0101	0.67	N/A	N/A	0.0006 (ND)	N/A	0.0051

**Table 7-5b**

Sample Location	Sample #	Sample Date	Matrix	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Lithium (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)
HC-4	PSC00004	10/23/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-4	PSW00009	11/7/96	Groundwater	N/A	N/A	N/A	0.0146	N/A	N/A	N/A	0.0001 (ND)	N/A
HC-4	PSF00007	10/24/96	Sump	N/A	N/A	N/A	0.0103	N/A	N/A	N/A	0.0001 (ND)	N/A

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 7-5a to 7-5f**  
**HC-4 Sample Results**  
 (Page 2 of 3)

**Table 7-5c**

Sample Location	Sample #	Sample Date	Matrix	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Strontium (mg/L)	Thallium (mg/L)
HC-4	PSC00004	10/23/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HC-4	PSW00009	11/7/96	Groundwater	N/A	N/A	0.0028 (ND)	N/A	0.0015 (ND)	N/A	N/A	N/A
HC-4	PSF00007	10/24/96	Sump	N/A	N/A	0.0028 (ND)	N/A	0.0015 (ND)	N/A	N/A	N/A

**Table 7-5d**

Sample Location	Sample #	Sample Date	Matrix	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)	Tritium (pCi/L) <sup>d</sup>	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Bismuth-214 (pCi/L)	Cesium-137 (pCi/L)
HC-4	PSC00004	10/23/96	Cuttings	N/A	N/A	N/A	N/A	N/A	N/A	ND <sup>f</sup> pCi/g <sup>e</sup>	0.18 pCi/g (ND)
HC-4	PSW00009	11/7/96	Groundwater	N/A	N/A	N/A	643	48.9	22.8	ND	6.32 (ND)
HC-4	PSF00007	10/24/96	Sump	N/A	N/A	N/A	11	5.24	5.15	ND	ND

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

**Table 7-5a to 7-5f**  
**HC-4 Sample Results**  
 (Page 3 of 3)

**Table 7-5e**

Sample Location	Sample #	Sample Date	Matrix	Lead-212 (pCi/L)	Lead-214 (pCi/L)	Potassium-40 (pCi/L)	Radium-226 (pCi/L)
HC-4	PSC00004	10/23/96	Cuttings	0.32 pCi/g	ND pCi/g	32.3 pCi/g	ND pCi/g
HC-4	PSW00009	11/7/96	Groundwater	ND	ND	70.3	ND
HC-4	PSF00007	10/24/96	Sump	ND	ND	ND	ND

**Table 7-5f**

Sample Location	Sample #	Sample Date	Matrix	Radium-228 (pCi/L)	Thallium-208 (pCi/L)
HC-4	PSC00004	10/23/96	Cuttings	ND pCi/g	0.17 pCi/g
HC-4	PSW00009	11/7/96	Groundwater	ND	ND
HC-4	PSF00007	10/24/96	Sump	ND	ND

<sup>a</sup>Milligram(s) per liter

<sup>b</sup>Not Analyzed

<sup>c</sup>Reported value is below detection limit

<sup>d</sup>Units in picoCuries per liter (pCi/L) unless otherwise noted

<sup>e</sup>PicoCuries per gram

<sup>f</sup>Not detected

## **8.0 Fluid Management**

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### **8.1 Summary of Fluid Management**

Fluid was managed during the Shoal Project through an FMP. This strategy provided guidance for the management of fluids generated during well drilling and construction activities. The FMP (DOE/NV, 1996c) used a fluid management decision strategy based on process knowledge and verification of process knowledge through laboratory analyses and field screening methodologies. One single-lined and one double-lined sump were constructed at each drill pad. The single-lined sumps (Sump #1) were used to contain uncontaminated fluids. The double-lined sumps (Sump #2) were built to contain contaminated fluids. The double-lined sumps were never used. Tritium levels in the drilling fluids did not even approach the Nevada Drinking Water Standard (NDWS) (NRS 445, 1996 and NAC 445A, 1996) of 20,000 picoCuries per liter (pCi/L). All fluids generated during drilling of the four wells were analyzed for lead and tritium. Tritium was monitored on an hourly basis, while lead was monitored every eight hours. Tritium was only detected in background concentrations, and lead results were at nondetectable levels. A fluid sample was collected from a sump and sent to an off-site laboratory for analysis at the completion of drilling operations when fluid from downhole was no longer being discharged into the sump.

### **8.2 Source Water for Drilling**

Source water for drilling came from water supply Well HS-1, located east of the project site in Fairview Valley. Water from Well HS-1 was sampled and submitted for analysis by Quanterra Labs. The water from this well was found to be below threshold limits for analytes as defined in the NDWS (NRS 445, 1996 and NAC 445A, 1996).

### **8.3 Sump Construction**

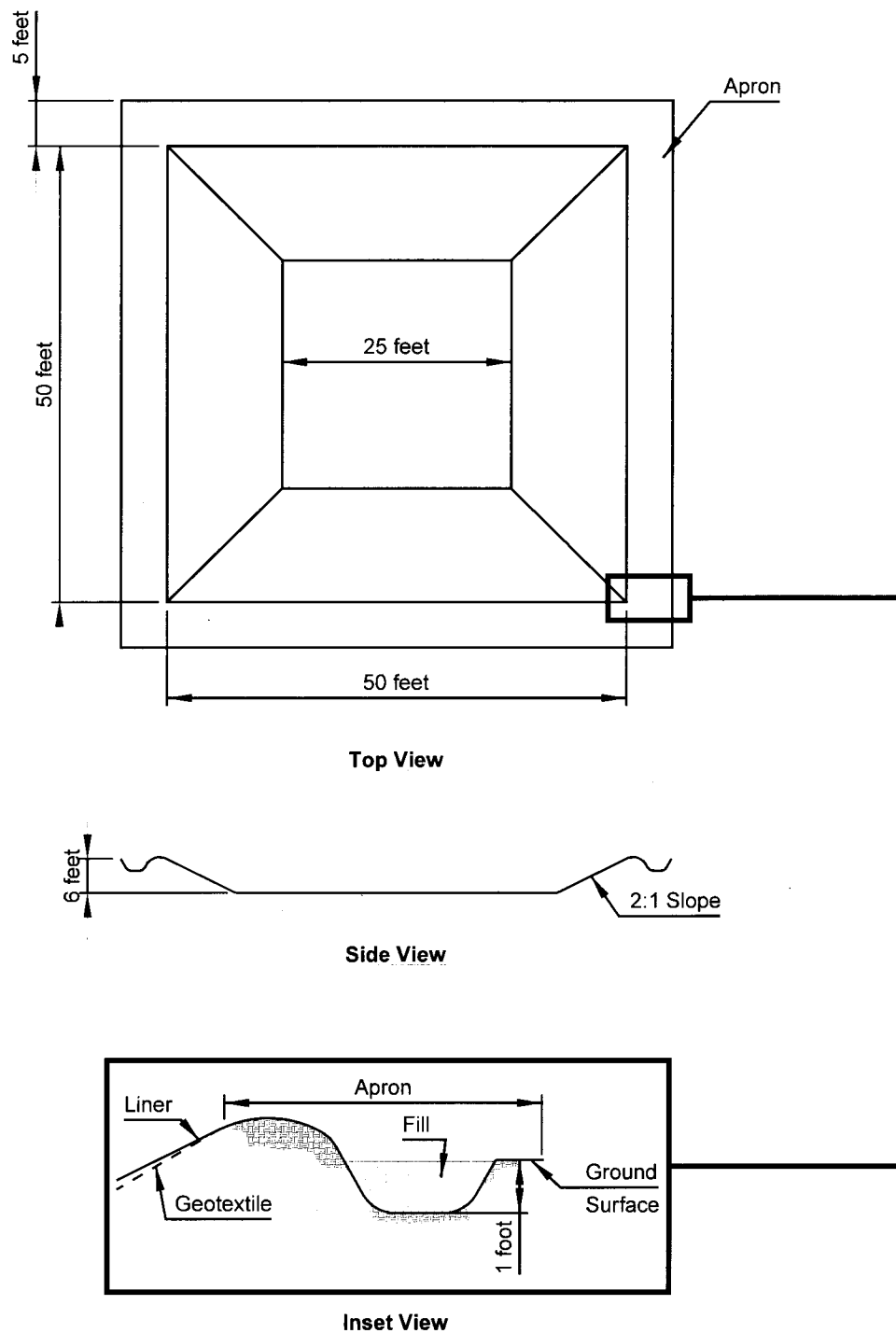
One single-lined and one double-lined sump were constructed at each drill pad according to the specifications established in the FMP for the Shoal Project Area (DOE/NV, 1996c). For details of sump construction, see sump construction diagrams, [Figures 8-1 and 8-2](#), included after the text. Each sump that was used to contain fluids also contains a wildlife escape ladder. The sumps are completely surrounded with orange construction fencing. In addition, flagging was strung across the sumps to discourage birds from landing in the sumps.

#### **8.4 Disposition of Fluids and Current Status of Sumps**

Drilling fluids from Wells HC-1, HC-2, HC-3, and HC-4 were discharged into their respective sumps: HC-1 Sump #1, HC-2 Sump #1, HC-3 Sump #1, and HC-4 Sump #1. When drilling operations were completed at each well, a composite sample was taken from Sump #1 for laboratory analysis. An “ER Fluid Disposition Tracking Form” was also filled out at this time to track the amount of fluid that was discharged into each sump. These forms are provided for reference at the end of this section as [Tables 8-1 through 8-4](#).

A letter dated December 4, 1996, to B. Bangerter (DOE Underground Test Area Subproject Manager) from P. Gretskey (IT Offsites Project Manager), indicated that all fluid management results for each of the sumps were below five times the NDWS. Therefore, the fluids could be released via overland flow.

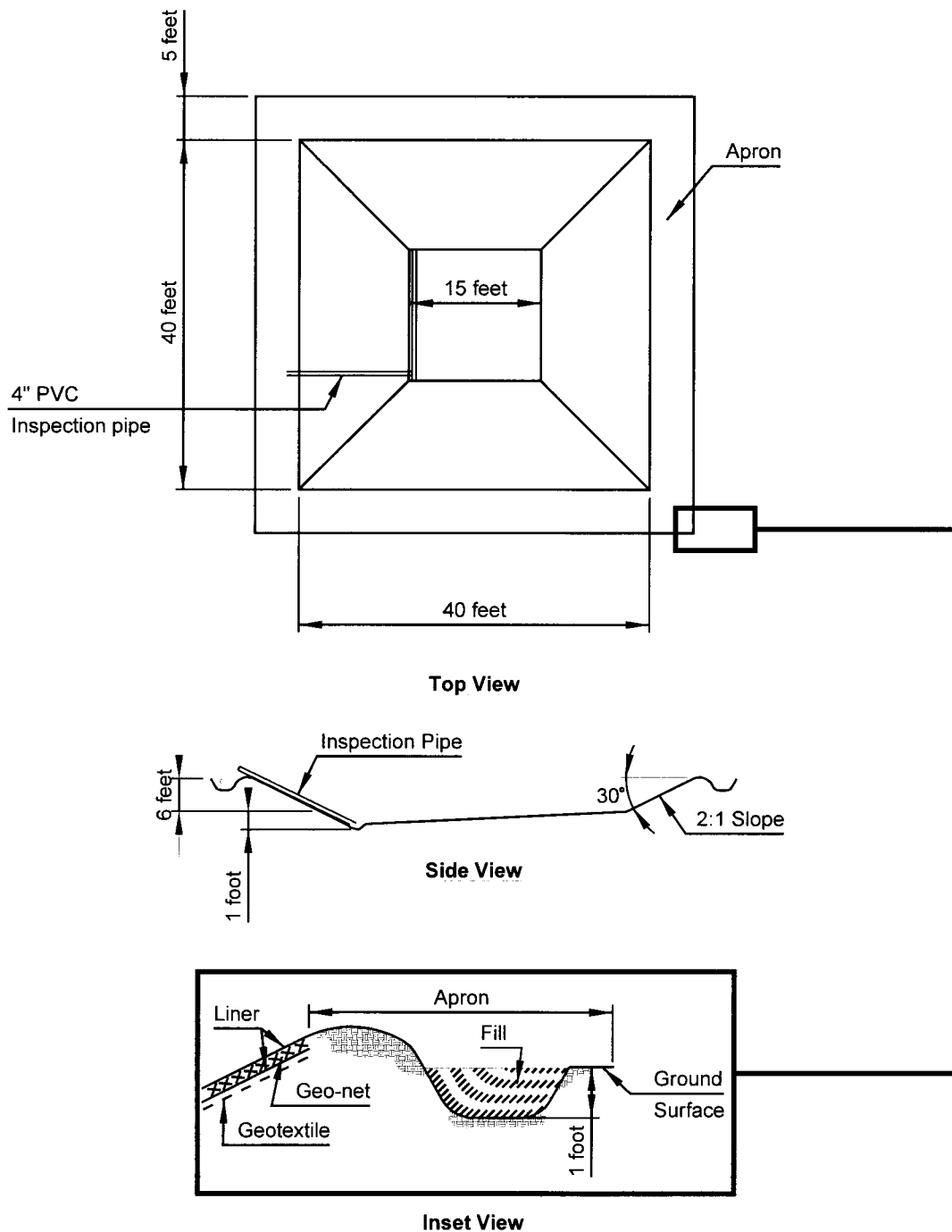
At the completion of hydrologic testing and Shoal Mud Pit remediation, all but two of the drilling sumps were closed. Approximately 600 gallons of water from the sump at HC-1 were discharged to the ground or used for dust control. All but two sumps were closed in place. One sump located at HC-3 and one at HC-4 are still used for fluid management during hydrologic testing of these wells. The liners were removed from the closed sumps and shipped to the NTS for disposal. The cuttings were buried in place and the areas graded. The sumps associated with HC-3 alternate drilling location were never used and therefore never lined. These sumps were pushed in and the area was also graded (IT, 1998).



**Note:**

Liner is a 65- by 65-foot flat sheet of 36-mil (0.036-inch) Hypalon.™

**Figure 8-1**  
**Diagram of Single-Lined Sump Construction**



**Note:**

Liners are 55- by 55-foot flat sheet of 36-mil (0.036-inch) Hypalon™.

Leak detection trench filled with +1/2 - 3/4" gravel.

**Figure 8-2**  
**Diagram of Double-Lined Sump Construction**

**Table 8-1**  
**Well HC-1 ER Fluid Disposition Status Reporting Form**

**Site Identification:** HC-1  
**Site Location:** Shoal Proj. Churchill Co. NV.  
**Site Coordinates:** N: 1621,993.0 E: 557623.4 approx.

**Well Classification:** Near Field  
**IT Project No:** 764044.03.07.00.00

**Report Date:** 10/27/96  
**DOE/NV Project Manager:** Janet Wing  
**IT Project Manager:** Paul Gretsky

**IT Site Representative:** Jeff Wurtz  
**IT Waste Coordinator:** Terre Maize

Well Construction Activity	Activity Duration		#Ops.D ays (A)	Well Depth (m)	Sump #1 (m <sup>3</sup> )		Sump #2 (m <sup>3</sup> )						
	From	To			Solids	Liquid	Solids	Liquid					
Stage I: Vadose-Zone Drilling	9/26/96	10/2/96	7	286.5	15.84	56.79	0	0					
Stage II: Saturated-Zone Drilling*	10/2/96	10/27/96	3	409.34	5.97	14.29	0	0					
Stage III: Initial Well Development*	10/2/96	10/27/96	4	409.34	0	45.39	0	0					
Stage IV: Final Development	na	na	na	na	na	na	na	na					
Stage V: Aquifer Testing	na	na	na	na	na	na	na	na					
<b>Cumulative Production Totals to Date:</b>			14	409.34	21.81	116.47							

(A) Operational days refer to the number of days that the drill rig was in operation during at least part of one shift.  
 (B) Solids volume estimates include calculated added volume attributed to rock bulking factors.  
 NA = Not Applicable; m = meters; m<sup>3</sup> = cubic meters; AIP = Analysis In Process  
 \* Well reentered and deepened, duration spans both initial drilling and deepening efforts.

**Tritium Curie Inventory:** Sump #1 (lined) = Fluids at natural background      Sump #2 (double-lined) = na  
**Total Device Capacities (m<sup>3</sup>):** Sump #1 = 219.0      Sump #2 = 219.0

**Remaining Device Capacity (Approximate) as of 10/27/96**      Sump #1 = 86.83 m<sup>3</sup>      Sump #2 = 219.0 m<sup>3</sup>

**Table 8-2**  
**Well HC-2 ER Fluid Disposition Status Reporting Form**

**Site Identification:** HC-2  
**Site Location:** Shoal Project Churchill Co. NV  
**Site Coordinates: N:**  
**Report Date:** 10/16/96  
**DOE/NV Project Manager:** Janet Wing  
**IT Project Manager:** Paul Gretskey

**Well Classification:** Near Field  
**IT Project No:** 768710.02.03.00.00  
**IT Site Representative:** Jeff Wurtz  
**IT Waste Coordinator:** Terre Maize

Well Construction Activity	Activity Duration		#Ops.D ays (A)	Well Depth (m)	Sump #1 (m <sup>3</sup> ) (lined/north)		Sump #2 (m <sup>3</sup> ) (lined/south)							
	From	To			Solids (B)	Liquid	Solids	Liquid						
Stage I: Vadose-Zone Drilling	10/6/96	10/15/96	5	335.28	18.22	30.60	0	0						
Stage II: Saturated-Zone Drilling	10/15/96	10/16/96	1	397.15	3.01	20.20	0	0						
Stage III: Initial Well Development	10/16/96	10/19/96	4	397.15	0	16.17	0	0						
Stage IV: Final Development														
Stage V: Aquifer Testing														
<b>Cumulative Production Totals to Date:</b>			10	397.15	21.23	66.97	0	0						

(A) Operational days refer to the number of days that the drill rig was in operation during at least part of one shift.  
 (B) Solids volume estimates include calculated added volume attributed to rock bulking factors.

NA = Not Applicable; m = meters; m<sup>3</sup> = cubic meters; AIP = Analysis In Process

**Tritium Curie Inventory:** Sump #1 (lined) = nil    Sump #2 (double-lined) =    Sump #3 (lined) =    Sump #4 (lined) =

**Total Device Capacities (m<sup>3</sup>):** Sump #1 = 219 m<sup>3</sup>    Sump #2 = 219 m<sup>3</sup>    Sump #3 = na    Sump #4 = na    Infiltration Area = na

**Remaining Device Capacity (Approximate) as of 10/20/96 :** Sump #1 = 130.8 m<sup>3</sup>    Sump #2 = 219 m<sup>3</sup>

IT Authorizing Signature/Date:

Table 8-3

## Well HC-3 ER Fluid Disposition Status Reporting Form

**Site Identification:** HC-3  
**Site Location:** Shoal Project Churchill Co. NV  
**Site Coordinates: N:**  
**Report Date:** 11/09/96  
**DOE/NV Project Manager:** Janet Wing  
**IT Project Manager:** Paul Gretskey

**Well Classification:** Near Field  
**IT Project No:** 768710.02.03.00.00  
**IT Site Representative:** Jeff Wurtz  
**IT Waste Coordinator:** Terre Maize

Well Construction Activity	Activity Duration		#Ops.D ays (A)	Well Depth (m)	Sump #1 (m <sup>3</sup> )		Sump #2 (m <sup>3</sup> )						
	From	To			Solids	Liquid	Solids	Liquid					
Stage I: Vadose-Zone Drilling	11/3/96	11/5/96	3	329.18	17.97	36.13							
Stage II: Saturated-Zone Drilling	11/5/96	11/9/96	5	397.15	3.26	74.42							
Stage III: Initial Well Development	NA	NA	0	NA	NA	NA							
Stage IV: Final Development													
Stage V: Aquifer Testing													
<b>Cumulative Production Totals to Date:</b>			8	397.15	21.23	110.55							

(A) Operational days refer to the number of days that the drill rig was in operation during at least part of one shift.  
 (B) Solids volume estimates include calculated added volume attributed to rock bulking factors.

NA = Not Applicable; m = meters; m<sup>3</sup> = cubic meters; AIP = Analysis In Process

**Tritium Curie Inventory:** Sump #1 (lined) = All fluids discharged were at background levels    Sump #2 (not lined) = NA

**Total Device Capacities (m<sup>3</sup>):** Sump #1 = 219.0    Sump #2 = not lined

**Remaining Device Capacity (Approximate) as of: 11/09/96**    Sump #1 87.22 m<sup>3</sup>    Sump #2 = NA m<sup>3</sup>

IT Authorizing Signature/Date:

**Table 8-4**  
**Well HC-4 ER Fluid Disposition Status Reporting Form**

**Site Identification:** HC-4  
**Site Location:** Shoal Project, Churchill Co. NV  
**Site Coordinates: N:**  
**Report Date:** 10/23/96  
**DOE/NV Project Manager:** Janet Wing  
**IT Project Manager:** Paul Gretskey

**Well Classification:** Near Field  
**IT Project No:** 768710.02.03.00.00  
**IT Site Representative:** Jeff Wurtz  
**IT Waste Coordinator:** Terre Maize

Well Construction Activity	Activity Duration		#Ops.D ays (A)	Well Depth (m)	Sump #1 (m³) (lined/north)		Sump #2 (m³) (lined/south)						
	From	To			Solids (B)	Liquid	Solids	Liquid					
Stage I: Vadose-Zone Drilling	10/20/96	10/22/96	2	318.39	18.75	24.98	0	0					
Stage II: Saturated-Zone Drilling	10/22/96	10/23/96	2	397.15	2.48	12.11	0	0					
Stage III: Initial Well Development	10/23/96	10/23/96	1	397.15	0	2 *	NA	NA					
Stage IV: Final Development	NA	NA	NA	NA	NA	NA	NA	NA					
Stage V: Aquifer Testing	NA	NA	NA	NA	NA	NA	NA	NA					
<b>Cumulative Production Totals to Date:</b>			5	397.15	21.23	39.09	0	0					

(A) Operational days refer to the number of days that the drill rig was in operation during at least part of one shift.

(B) Solids volume estimates include calculated added volume attributed to rock bulking factors.

\* Well development fluid volumes estimated from water production rates during development session.

NA = Not Applicable; m = meters; m³ = cubic meters; AIP = Analysis In Process

**Tritium Curie Inventory:** Sump #1 (lined) = All sump fluids at natural background activities! Sump #2 (double-lined) =

**Total Device Capacities (m³):** Sump #1 = 219 m³ Sump #2 = 219 m³ Infiltration Area = na

**Remaining Device Capacity (Approximate) as of 10/23/96 :** Sump #1 = 158.7 m³ Sump #2 = 219 m³

## **9.0 Waste Management**

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IT was responsible for waste management and environmental compliance at the PSA. Generated waste included sanitary waste, hydrocarbon waste, and decontamination rinsate. Analytical data for the waste associated with the site characterization project was reviewed to determine its regulatory status. The analytical data indicated that the waste is not regulated for hazardous constituents and is below performance objective criteria for radioactive waste. Therefore, the non-liquid waste was disposed of as sanitary waste. Hydrocarbon waste was disposed of by the drilling contractor. Only one 55-gallon drum of decontamination rinsate was generated during the Shoal Mud Pit characterization and was classified as non-RCRA rinse water. This drum was transferred to the Nevada Test Site (NTS) and the contents were disposed of as sanitary waste in the Area 6 sanitary sewage lagoons.

### **9.1 NVO-325 Protocols**

The Shoal Project was conducted under the protocols of NVO-325 Waste Management procedures. NVO-325 (DOE, 1992) is DOE Nevada's criteria for acceptance of radiological waste at the NTS and is also designed to prevent the generation of mixed waste. Therefore, every product used on the Shoal site had to have an approved Material Safety Data Sheet (MSDS) prior to being brought to the site. These approved MSDSs were kept on location in the Shoal Project office trailer.

Waste generated during soil and fluid sampling was held pending analysis of associated samples. Waste items were tagged and labeled to ensure traceability back to the samples. When the analytical results for the samples came back below the performance objective criteria, these were disposed of as sanitary waste.

### **9.2 Results of Waste Management Audit**

A Waste Management Audit was conducted by IT Corporation Environmental Compliance Department at the Shoal Project Site on October 4 and 5, 1996. The Shoal Project successfully passed this audit with no findings.

### **9.3 Disposition of Waste**

Waste generated as part of sampling activities was disposed of as sanitary waste as the analytical data indicated that the waste is not regulated for hazardous constituents and is below performance objective criteria for radioactive waste. The hydrocarbon waste was disposed of by the drilling

subcontractor. The one drum of decontamination rinsate generated during the Shoal Mud Pit characterization was disposed of as sanitary waste in the Area 6 sewage lagoons at the NTS.

## 10.0 References

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